THE ENGINEER

A Seven-Day Journal

Sir David Pye Elected President of the "Mechanicals"

At the annual general meeting of the Institution of Mechanical Engineers, which was held in London last Friday evening, Sir David Randall Pye, C.B., D.Sc., M.I.Mech.E., F.R.S., was installed as president in succession to Mr. A. C. Hartley. Sir David has been Provost of University College, London, since 1943, prior to which he was for several years Director of Scientific Research at the Air Ministry. He was educated at Tonbridge School and at Trinity College, Cambridge, of which he was a scholar in natural science. After a period in the works of Mather and Platt, Ltd., Sir David was appointed assistant to the Professor of Engineering Science at the University of Oxford and in 1911 was elected a Fellow of New College, Oxford. During the first world-war he held a commission in the Royal Flying Corps and the Royal Air Force. In the summer of 1919 Sir David was invited to become a Fellow and Lecturer at Trinity College, Cambridge, and during the six succeeding years, apart from teaching at Cambridge, he was engaged in research on the combustion of volatile fuels, in collaboration with Ricardo and Co., Ltd., and Sir Henry Tizard. In 1925 the Air Ministry initiated a Directorate of Scientific Research under Dr. H. E. Wimperis, and Sir David was appointed deputy director. He succeeded Dr. Wimperis as director in 1937 and continued in that office until 1943, by which time it was decided that the research programme could be limited to projects which might be expected to become effective weapons of war within two years. Under the circumstances, Sir David was permitted to resign his post as Director of Scientific Research in order to become Provost of University College, London. He was created a Knight Bachelor in the recent New Year Honours. Sir David is a Fellow of the Royal Society and of the Royal Aeronautical Society, and is also an Honorary Fellow of the Institute of Aeronautical Sciences (U.S.A.) and of University College, London. He became a full member of the Institution of Mechanical Engineers in 1934, has served on the council since 1943, and was elected a vice-president in 1947.

Super Priority Armament Production Scheme

Last week the Ministry of Supply announced in detail the scheme, mentioned by the Prime Minister on March 5th, of awarding super priority status to certain items of rearmament. It applies principally to aircraft production, guided missiles and the radar defence chain. The aircraft to benefit are the Hawker "P 1067," now called the "Hunter," and the Vickers "Swift," both day interceptor aircraft; two bombing aircraft, the Vickers "Valiant" and the English Electric "Canberra," all four aircraft employing the Rolls-Royce "Avon" turbo-jet engine; either the "DH 110" or the delta wing "GA 5" all-weather, multi-purpose fighter, whichever is awarded the production contract, these aircraft taking twin "Avon" and "Sapphire" engines respectively, and the Fairey "Gannet" naval machine with a double "Mamba" turbo-prop installation. The scheme also embraces certain anti-mine devices and the "Centurion" tank, and extends where appropriate to cover equipment and ammunition for all the weapons in the scheme. For the priority scheme to be effective a further 78,000 personnel are required in the aircraft industry itself, and it is hoped that the dire need for these items alone will induce skilled tradesmen particularly to co-operate in the recruitment programme. Contractors and sub-contractors requiring labour and materials for production of these items will quote the words "Super Priority" and contract numbers. If necessary, and after reference to the Ministry, the priority can be used to expedite the completion or delivery of buildings and plant required in their production.

Thomas Gray Memorial Lecture

This year's Thomas Gray Memorial Lecture, entitled "The Rolling of Ships," was given before the Royal Society of Arts on March 26th by Professor A. J. Sims, R.C.N.C. The paper mentioned that motion sickness is caused mainly by high linear accelerations and went on to enumerate a few of the advantages of reduced rolling, particularly the reduction of risk of a ship being lost. Four factors influencing rolling were listed, these being the standard of stability, which defines a tender or stiff ship, and which governs the amplitude of rolling, and the inertia of the ship linked with the position of weights in relation to the axis of rolling. The third factor is the damping action developed by the rolling of the ship in which the ship's store of energy, caused by rolling, is dissipated, by setting in motion the water close to the ship and the creation of a shallow wave. The fourth factor is a dynamic problem concerned with the response in wave systems. The contribution of model experiments towards assessing rolling performance was briefly considered, and the paper went on to discuss the history of special equipment to reduce rolling and the schemes tested, which include movement of solid weights, water movement, gyroscopes and external fins. Early activated weight experiments by the late Sir John I. Thornycroft in the "Cecile" were recalled and also the activated water transfer system in the cruiser "Prinz Eugen," and the minesweeper "Peregrine." The gyroscopic system as fitted in the destroyer "Vivien" was mentioned, also the much larger installation, consisting of three 110-ton spinning elements, mounted in the "Conte di Savoia," of 41,000 tons displacement. The activated fin group was extensively described and particular reference made to the Denny-Brown stabilisers, as developed and fitted to the cross-Channel steamer "Isle of Sark" in 1936, and the much larger gear fitted in the passenger liner "Chusan" in 1950. In the latter vessel a roll of 34 deg. amplitude, out to out, was induced in the high-speed range by reversal of the fins, and voyage reports indicate that the equipment has given excellent results. Activated fin or water systems, it was stated, are those likely to be used in the future, and the success of recent installations suggests that the fitting of this gear to liners will remove the principal disadvantage of sea travel. Models of various anti-rolling devices were on view and the lecture was illustrated by a number of films.

Institution of Mechanical Engineers Southern Branch

On Wednesday of last week, the Southern Branch of the Institution of Mechanical Engineers celebrated its "coming of age" at a dinner and dance at the Polygon Hotel, Southampton. That function took place a few weeks later than the actual date it was held to celebrate, for the inaugural meeting of the branch took place at Portsmouth on January 8, 1931. On that occasion the Lord Mayor welcomed the formation of the branch, and Mr. L. St. L. Pendred, president of the Institution, made an inaugural address in reply to him. The branch was particularly fortunate in having as its "parents" two men admirably suited to set it going. The initiative lay with Dr. Abbott, at that time Head of the Engineering Department of Portsmouth Municipal College. It was primarily his determination and tact, combined with the clarity with which he was able to state his opinions, that made a start possible. The other man concerned was Eng.-Admiral Sir George Goodwin, who wholeheartedly supported Dr. Abbott and became the first chairman of the branch. Though he was never president of the Institution, he had nevertheless a very clear understanding of all the Institution could do to help its members and of the value to members of setting up the new branch. He was followed as chairman by Wing-Commander Cave-Browne-Cave. The present chairman is Mr. R. D. Peggs. The area of the branch extends along the coast from Brighton to Weymouth and far inland besides. To begin with, its work centred around Southampton and Portsmouth. But latterly it has shown signs of shifting to Farnborough. One of the distinctions of the branch is that Mr. James Clayton, who so greatly benefited the Institution under his will, lived within its area.

Lloyd's Register Annual Report

This week Lloyd's Register of Shipping issued its 1951 annual report, and in the Foreword some comparisons are made with 1851, which illustrate the enormous growth of the Register. In twelve months the world merchant fleet has increased by 2,600,000 tons gross, and the demand for new tonnage has not slackened. The world fleet, totalling 87,245,044 tons gross, is 27 per cent greater than the pre-war figure, and of this total more than 20 per cent is represented by tanker tonnage, which stands at 18,210,287 tons gross, a figure approaching a 60 per cent increase over 1939, and indicating the increasing world consumption of oil. The report states that rather less than the normal amount of tonnage is being scrapped and calls attention to the tables which indicate the age distribution of the fleets of individual countries. It is noted that 19 per cent of the world fleet is over twenty-five years old. In the report one table gives the flag distribution of world tonnage, the British Commonwealth owning 25·4 per cent, and another table, which graphically indicates the tonnage of new ships completed and classed annually, shows the increase in the tonnage building in countries abroad. According to the report, 472 ships, of 2,151,882 tons gross, were completed to the Society's classification during the year, which represents 60·5 per cent of the world total. The quantity of steel tested by the Society's surveyors increased by 340,000 tons over the 1950 total, and the report goes on to discuss welding and mentions the provision of mild steel having adequate notch toughness, the extension of radiographic control of welding, and the extent of welding in the construction of pressure vessels. It is stated in the report that trends and developments have continued to maintain the tendencies given in the previous year: oil tankers have increased in deadweight, more ships have machinery fitted aft, more cargo carriers have fore and aft framing at deck and bottom, corrugated bulkheads are increasingly favoured, and speeds continue to become higher. The research staff has studied deflection problems associated with loading conditions, and also the question of cargo distribution. Other investigations undertaken, it is stated, concern hull vibration, torsional vibration in shafting systems, and tail shaft failures.

Present-Day Locomotive Working in Great Britain

No. VI*—FIRST RESULTS FROM THE "BRITANNIAS"

By O. S. NOCK, B.Sc., M.I.C.E., M.I.Mech.E.

During the summer of 1951 locomotives of the new "Britannia" class went into regular service on various routes of the Eastern, Southern and Western Regions. This article covers footplate observations of their running on a variety of passenger trains, and discusses the driving and firing methods used on different routes. Variations in fuel are noted, and operating conditions resulting from gradients, speed restrictions and train loading are summarised for such diverse train services as the accelerated London–Norwich expresses, the "Golden Arrow" boat express, and the "Cornish Riviera Express" over the severe gradients west of Plymouth.

IN discussing any results of working with the new standard "7MT Pacifics" of British Railways one is conscious of altered values in the assessment of locomotive performance. And by "performance" it is overall performance that is now meant, not merely an ability to make successful runs on low fuel consumption, but to continue to do so on a minimum of day-to-day servicing, month after month; to sustain a high standard of thermal efficiency and road worthiness; and, above all, to maintain that high availability that enables a high weekly and monthly mileage to be made. To what extent the new engines will fulfil these aims of the Railway Executive it is hardly possible to predict, as yet. If past history provides any criterion it will be several years before the success or otherwise of the new design is definitely established, since there are so many factors, psychological as well as engineering, that can come to bear upon the case. So far one can do little more than record their comings and goings in different parts of the country, and the similarities and contrasts they provide with existing classes of comparable tractive power.

It is only natural that the road performance of engines on which we all have a proprietary interest should have been most keenly watched from the very outset, and already there are certain facets of their general running which would appear to be pointers towards their ultimate and complete success. In the meantime it is no secret that teething troubles have been experienced, as they were in the past with engines that to-day have achieved positions of unquestioned renown. The following notes are therefore in the nature of a preliminary report, made as a result of riding some 650 miles on the footplate with various engines of the class, and seeing them at work in the Western, Southern, Eastern, and London Midland Regions. All the individual engines with which I rode were relatively new, and in only a few cases could it be said that the enginemen were thoroughly familiar with them. In two instances I rode with drivers who were making their very first trips on engines of the "Britannia" class. Table I shows some of the duties regularly worked, though I have not so far had the opportunity of sampling every one from the footplate.

TABLE I.—*Working of "Britannia" Class Engines*

Region	Route	Daily mileage
Eastern ...	Liverpool Street-Norwich and back	230
Southern ...	Waterloo—Bournemouth West and back	223
	Victoria—Dover Marine and back†	156
Western ...	Paddington—Wolverhampton and back	246
	Paddington—Bristol and back	236½
	Plymouth—Bristol and back...	256
	Paddington — Plymouth (via Westbury) (down or up, one way only)	225½
	Plymouth—Penzance, two return trips	318

† In certain cases three single trips worked, totalling 234 miles daily.

While engine crews and supervisory running staff have been gaining familiarity with the new engines no very intensive rosters have been attempted; neither has any use been made of the "mixed traffic" character of the design, by working out composite duty rosters including the operation of fast goods, as well as passenger trains in the course of a single round trip. These, no doubt, will come later, when the overall capabilities of the class have been generally assessed by the operating department. In the meantime it is certainly a tribute to a mixed traffic class that it should have been used, so far, almost exclusively in express passenger traffic. Some typical examples of trains worked are given in the accompanying Table II.

Without much doubt the hardest regular task set to the new engines has been the haulage of the "Bournemouth Belle," an all-Pullman train, liable to load up to 500 tons tare weight at holiday periods. This train has been successfully worked in the heaviest conditions of loading, and run non-stop between Waterloo and Southampton at the booked average speed of 54·7 m.p.h. without any chance of the water supply being replenished *en route*. In special cases, too, non-stop runs have been made on the Western Region over the 142·7 miles between Taunton and Paddington without taking water intermediately. While water consumption does not always give an infallible guide to fuel consumption, the two quantities remain closely related even with variations in footplate methods. With engines using a high degree of superheat the evaporation usually lies between 7·5 lb and 8·5 lb of water per pound of coal. Table III gives details of some actual recorded work on the Eastern, Southern and Western Regions. Of these runs, only Nos. 11 and 12 were not observed from the footplate by the author. No. 11 was the demonstration run with the dynamometer car made on May 18, 1951, while No. 12 is included as an example of unusually fast running with one of the moderately loaded East Anglian trains.

Unconsciously there appears to have developed a general agreement between enginemen of the various regions as to the most effective method of driving. The days are passing when it was considered inefficient to handle a modern locomotive with anything but full open regulator and the shortest possible cut-off. Many well-known types seem to respond equally well to "driving on the throttle" or "driving on the reverser," and the "Britannias," generally speaking, are driven on the throttle, with the cut-off at 20 to 25 per cent. But there does not seem to be any reluctance among drivers to lengthen the cut-off considerably on heavy stretches of the road, and spells at 30, 35 and even 40 per cent were frequent on some runs.

TABLE II.—*Some Trains Run by "Britannia" Class Engines*

Region	Route	Mileage	Booked* average speed, m.p.h.	Maximum load, tons (tare)	Nature of route
Eastern ...	Liverpool Street-Ipswich	68·7	54·2	300	Undulating; two moderate slacks
Eastern ...	Ipswich-Norwich	46·3	54·4	300	Undulating (easy)
Southern ...	Waterloo-Southampton ...	79·3	54·7	500	Undulating (easy)
Western ...	Paddington-Bath	106·9	56·7	455	Almost level
Western ...	Westbury-Taunton	47·3	55·7	455	Undulating (easy)
Western ...	Penzance-Plymouth ...	79·5	37·5†	420	Very severe; includes three stops; maximum speed permitted 60 m.p.h.

* Start to stop, except on run marked †

"BRITANNIA" CLASS ENGINE No. 70009 "ALFRED THE GREAT"

* Previous articles in this series were: No. I, "The L.N.E.R. 2-6-2 'Green Arrow' Class," October 11, 1946; No. II, "The L.M.S.R. 'Coronation' Class 'Pacifics,'" December 13 and 20, 1946; No. III, "The G.W.R. Oil-Fired 4-6-0s," February 6 and 13, 1948; No. IV, "The Mixed Traffic 4-6-0s," November 4, 11, 18 and 25, 1949; No. V, "The Western Region 'Castle' Class," April 20 and 27, 1951.

TABLE III.—*Recorded Work of "Britannia" Class Engines*

	Region	Route	Miles	Actual time, min	Net time, min	Net average speeds, m.p.h.	Engine number	Load, gross tons behind tender	Type of coal	Water consumption, galls./mile
1	Eastern ...	Liverpool Street-Ipswich	68·7	78½	72	57·2	70,000	320	Hard	28·4
2	,,	Ipswich-Norwich	46·3	49½ *	48½	57·3	70,000	320	,,	28·1
3	,,	Norwich-Ipswich	46·3	47½	47½	58·5	70,002	310	,,	32·4
4	,,	Ipswich-Liverpool Street	68·7	87½	72	57·2	70,002	310	,,	30·6
5	Southern ...	Victoria-Dover Marine	78·0	96	91½	51·2	70,004	395	Small hard	29·5
6	Western ...	Westbury-Taunton	47·3	50½	50½	56·5	70,021	380	Soft Welsh	25·4
7	,,	Taunton-Exeter	30·8	37	37	50·0	70,021	380	,,	26·0
8	,,	Newton Abbot-Plymouth	31·8	46½	46½	41·3	70,021	250	,,	34·6
9	,,	Exeter-Taunton	30·8	35	34	54·3	70,022	345	,,	32·9
10	,,	Bridgwater-Bristol	33·2	40½	37	53·9	70,022	345	,,	24·4
11	Midland ...	Rugby-Euston	82·6	87½	79	62·7	70,009	470	Mixed	*
12	Eastern ...	Norwich-Ipswich	46·3	43½	43	64·7	70,013	330	—	*

* Not observed from footplate by author

TABLE IV.—*Western Region—Taunton-Whiteball*

Engine number		5,029			1,015			70,021			18,000			6,022		
Engine name		"Nunney Castle"			"County of Gloucester"			"Morning Star"			Gas turbine†			"King Edward III"		
Engine class		("Castle")			("County")			("Britannia")			—			("King")		
Load, tons gross, behind tender		355			380			380			375			375		
Engine power class		7P			7MT			7MT			—			8P		
Miles		min sec	m.p.h.	%	min sec	m.p.h.	%	min sec	m.p.h.	%	min sec	m.p.h.	%	min sec	m.p.h.	%
0·0	Taunton ... ... Dep.	* 0 00	60	15	0 00	—	—	0 00	—	—	0 00	—	—	0 00	—	—
2·0	Norton Fitzwarren	2 00	60	15	4 02	—	—	3 57	—	25	4 50	—	—	3 50	—	20
3·9	Milepost 167	—	—	15	—	—	—	6 15	—	25	6 51	—	—	6 05	—	20
5·9	Milepost 169	—	—	20	—	—	—	8 41	—	30	8 52	—	—	8 19	—	20
7·1	Wellington	7 38	53	20	9 35	56	—	10 16	50	30	10 07	63½	—	9 44	56	25
7·9	Milepost 171	8 30	50	25	—	—	—	11 11	47	32	10 51	—	—	10 32	—	25
8·9	Milepost 172	9 48	44½	25	—	—	—	12 34	41½	36	11 55	—	—	11 43	—	30
9·9	Milepost 173	11 23	34	25	12 53	42½	—	14 09	36½	36	13 07	45	—	13 05	41	25
10·9	Whiteball (174) ... ... Pass	13 09	35	—	14 24	39½	—	15 48	37	—	14 28	41½	—	14 30	42½	—
	Time over 3·8 miles, Wellington-Whiteball	5 31	—	—	4 49	—	—	5 32	—	—	4 21	—	—	4 46	—	—

* Times from passing Taunton at 60 m.p.h. † See THE ENGINEER, May 19th and 26th, 1950 for description of this run.

The firing varied. On modern locomotives that steam freely one sometimes sees careless or perhaps thoughtless work by young firemen, and less excusably by some who should have learned better. The "Britannias" were sometimes the victims of such lack of method, though on the Western Region the skill displayed by men brought up in the traditions of the Great Western Railway produced remarkable results, in a rock-steady rate of combustion and constant boiler pressure, just below blowing-off point, for half hours at a stretch. With soft coal the usual "haycock" formation of the fire was used, but with the ridge athwartships, instead of longitudinally, as on the narrow firebox Swindon engines. On the outward bound "Golden Arrow" of the Southern Region some loss of pressure occurred in the early stages with a thick fire of hard small coal. The young fireman, keen as he was, was slow to use the dart, while the driver was intent upon threading the intensely signalled London suburban area, and could not give his mate much in the way of advice. Once the summit at Knockholt was breasted the pressure was quickly rallied and subsequently maintained well during a spell of fast running through the Weald.

Some details of running on various stretches of line will be of interest:—

(*a*) Romford and Brentwood bank: engine 70,000, load 320 tons gross behind tender. The train was slackened to walking pace at Romford, and then with 30 per cent cut-off accelerated to 57 m.p.h. in 3¾ miles of 1 in 380 ascent. With cut-off 35 per cent fell from 57 to 42 in 2¼ miles of 1 in 103, and with 40 per cent took the last mile of the bank, half at 1 in 85 and half at 1 in 155 at minimum speed of 38½ m.p.h.

(*b*) Swainsthorpe to Claydon, Ipswich-Norwich line: engine 70,002, load 310 tons gross behind the tender. Average speed for 36·1 miles of undulating road 67·7 m.p.h. Gradients varying, but nowhere very long or steep; average inclination 1 in 3540 down. Cut-offs 20 to 25 per cent; steam chest pressures 130 lb to 210 lb per square inch.

(*c*) Staplehurst to Westenhanger, Dover line: engine 70,004; load 395 tons gross behind tender. Average speed for 22·3 miles of steadily rising road, average gradient 1 in 680, 67·3 m.p.h. Cut-offs 25 to 28 per cent; steam chest pressure 180 lb to 210 lb per square inch.

(*d*) Bridgwater-Worle Junction, Western Region: engine 70,022, load 345 tons gross behind tender. Following permanent way restrictions to 40 m.p.h., acceleration on level track from 40 to 78 m.p.h. in 12·2 miles. The actual rate of acceleration can be seen from the accompanying table:—

Miles	Speed
0	40
3·2	58
6·0	69½
7·9	72
9·9	75½
12·2	78

Cut-off was 25 per cent throughout and steam chest pressure 215 lb to 225 lb per square inch. Acceleration had not ceased, but the steaming was eased as speed had begun to exceed the 75 m.p.h. limit imposed on this stretch of line.

On the climb from Wellington, Somerset, to Whiteball tunnel one of the new engines showed up well and some comparative details of good climbs with engines of Great Western design are included in Table IV. The line is practically level out to Norton Fitzwarren, followed by a continuous rise, steepening from 1 in 369 to 1 in 170, extending almost to Wellington Station. The worst part of the bank lies between Mileposts 170½ and 173, where the gradient is successively 1 in 90, 86 and 80, followed by nearly a mile through Whiteball tunnel on 1 in 127. The new "Pacific," No. 70,021, "Morning Star," showed a drop of only 13½ m.p.h. between Wellington and the tunnel entrance and, what was more noteworthy, a drop of only 5 m.p.h.

TABLE V

Miles		Miles accumulated	Booked time	Actual time
			h min	h min
0·0	Penzance		9 45	9 45
5·6	St. Erth	5·6	9 54	9 55
0·0			9 57	9 58
5·0	Gwinear Road ...	10·6	10 7	10 9½
0·0			10 10	10 11
4·1	Carn Brea ...		10 18	10 18½
10·0	Chacewater ...		10 26	10 26
15·2	Truro...	25·8	10 34	10 33
0·0			10 40	10 40
7·7	Grampound Road		10 52	10 51
14·5	St. Austell... ...		11 2½	11 00
19·0	Par	44·8	11 9	11 6
0·0			11 14*	11 10
7·8	Bodmin Road ...		11 27	11 24
16·9	Liskeard		11 42	11 39
30·5	Saltash		12 1	11 56½
34·7	Plymouth... ...	79·5	12 10	12 6

* Public time 11.10 a.m.

TABLE VI

Time min sec	Cut-off	Water consumpt'n
0 00	Linking up	0
6 30	30	
8 15	Coasting and stop	—
13 10	50	
(Leaving St. Erth)	(Linking up)	
14 40	31	
17 30	40	
18 30	45	
20 30	50	
21 30	54	
23 15	Coasting and stop	550
26 15	55	
(Leaving Gwinear Road)		
28 10	40	
29 15	45	
30 25	50	
33 40	30	
40 35	Coasting and Truro stop...	1250
54 50	44	
(Leaving Truro)		
57 45	35	
58 45	30	
60 00	Coasting	—
62 40	30	
64 40	40	
65 55	33	
68 45	30	
70 38	40	
71 45	Coasting and Par stop ...	2450
85 20	55	
(Leaving Par)		
86 30	47	
91 35	Coasting	—
93 55	28	
96 40	30	
101 40	40	
102 07	42	
105 35	40	
108 10	33	
109 18	Coasting and easy into Plymouth	3450
141 00	End of run	
(Arrival at Plymouth)		

Total water consumption 43 gallons per mile.

in the last mile of this "2¼." It is unfortunate that no observer was on the footplate of the "County" class engine No. 1015, so that no details of the working are available on what must have been a fine piece of work. The "Castle" passing Taunton at speed with the down "Cornish Riviera" express was taken up under relatively easy steam. It should be added that the figures in the column for percentages of cut-off are opposite to the locations at which the changes were made; for example, with No. 70,021 cut-off was advanced to 32 per cent when the engine was near the 171st milepost.

The most interesting personal experience, however, was that on the up "Cornish Riviera" express from Penzance to Plymouth on a day when it was made up to within one coach of full load—actually 389 tons tare, 420 tons with passengers and luggage. The mileages, booked times and actual times are shown in Table V.

The actual locomotive effort involved can be better appreciated from a log showing the engine working in relation to the journey time, and this is shown in Table VI. The times shown in column 1 are those when change was made to the cut-off shown in column 2. The firing of the engine was well managed throughout; the fluctuating demands for steam were met with practically nothing in the way of blowing off, and even when working continuously at more than 40 per cent cut-off there was never any suggestion of the cylinders beating the boiler.

As will be seen from this table, the spells of hard uphill work are interspersed with quite lengthy periods of coasting and stops, as with the fourteen-minute interval ending with departure from Truro, and the similar interval up to departure from Par. To conclude there comes a period of half an hour when the engine was being lightly steamed or coasted.

The Cold Cathode Gaseous Discharge as a Switching Device

By N. L. HARRIS, B.Sc., F.Inst.P.*

Cold cathode gaseous discharge tubes can be used advantageously instead of mechanical switches or relays, particularly in circuits where extreme speed of operation is important. Frequently cold cathode tubes can do the work of thermionic valves or gas filled relays and without the need for cathode heating. Among the applications described in this article are circuit protection, and switching devices in radar.

THE extent to which cold cathode gaseous electric discharge devices can replace mechanical switches or relays in many circuit applications is not always fully appreciated. In certain cases the discharge tube will have definite advantages and give a performance unattainable by mechanical means. This statement is particularly true when the switch is required to act only under certain circuit conditions or when extreme speed in operation is necessary. Discharge tubes can be designed to remain inoperative until the circuit potential rises above a designated value or they may be arranged to function only when a voltage pulse of defined magnitude is applied to them. When speed of operation is important the mechanical inertia of the moving parts of a mechanical switch can be replaced by the extremely small "electrical inertia" associated with the initiation and building-up of the gaseous discharge. Thermionic valves or gasfilled relays with thermionically emissive cathodes can frequently be replaced by cold cathode discharge tubes which will perform similar functions without needing a continuous supply of energy to maintain the cathodes at emissive temperatures.

Protection of Circuits or Apparatus

One well-defined application of gas discharge switches is the protection of circuits or apparatus against voltage surges or excess line voltages. Discharge tubes have a definite starting voltage and pass no current, or negligibly small currents, at applied voltages below this value. They can be designed to start at any desired voltage from a lower limit below 100V d.c. or a.c. up to values of the order of kilovolts. By careful design and controlled manufacture the actual starting voltage can be held constant within comparatively small tolerances, particularly in the case of tubes operating at voltages up to some 200V, where the variation from tube to tube may be as small as 1 to 2 per cent. Once the discharge has started, the tube, which often operates in these circuits without a series impedance, will pass a substantial current and the voltage across it will usually be maintained at a value below the starting voltage. Such a tube connected across a line will therefore protect apparatus in the circuit against damage from over-voltage conditions and if the electrode system in the tube is

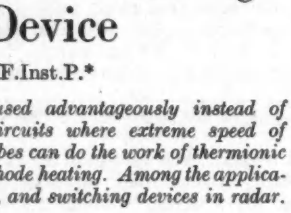


FIG. 1—"CCB" ARRESTER

generously designed the surge current can be maintained long enough for mechanically operated relays to operate and clear the fault. The tube will then extinguish and remain ready for operation again should another fault occur.

In the simplest case, where, for example, telephone equipment connected to lines normally operated at 20V is to be protected against surges induced by lightning or from adjacent power lines, a discharge tube starting at a few hundred volts is all that is necessary. In such cases the tube may be provided with three electrodes, the middle one of which is earthed, the outers being connected to the two lines (Figs. 1 and 2). Each

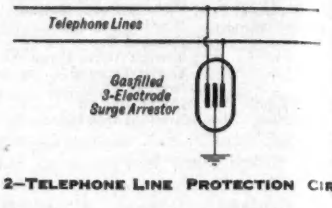


FIG. 2—TELEPHONE LINE PROTECTION CIRCUIT

line then has an independent discharge path to ground, and the system is self-clearing, the tube extinguishing each time the surge dies away.

If line circuits, which normally operate at some 100V to 200V, require protection against induced voltage surges of similar magnitude, difficulties may arise from a tendency of the surge arrestor tube to remain in continuous operation at the normal line voltage once it has been started by the surge. It is in such cases that auxiliary mechanical switches may be necessary to disconnect the line and extinguish the tube. One arrangement (Fig. 3) which has been used to protect low

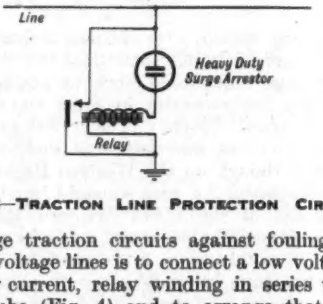


FIG. 3—TRACTION LINE PROTECTION CIRCUIT

voltage traction circuits against fouling by high voltage lines is to connect a low voltage, heavy current, relay winding in series with the tube (Fig. 4) and to arrange that the relay contacts, which are heavy duty contacts, wedge themselves together on operation, shorting the tube and earthing the line. Other trip gear is then brought into operation and the discharge tube, as well as the traction apparatus, is protected from continuous overload.

Similar principles may be applied, at the other end of the scale, to the protection of laboratory equipment. It is a simple matter, for example, to provide a voltmeter with a

FIG. 4—"CCA" ARRESTER

* Research Laboratories of The General Electric Company, Ltd., Wembley, England.

small discharge tube connected across its input terminals, which will protect the instrument from damage should it be accidentally connected to an excessively high voltage supply. Discharge tubes may also be used to protect condensers from being charged to potentials likely to damage the dielectric and they may also be used to absorb surges produced accidentally in a network, for example, by the discharge of a condenser or the breaking of current through an inductance.

In all these applications of surge arrestors it will be noticed that the vital characteristics of the tube are its starting potential, its extinguishing potential and the current surge which it can handle without its electrodes being damaged or its characteristics impaired. Overheating of the electrode system, for example, may significantly alter the starting voltage. The maximum surge capacity is conveniently measured in terms of the product of surge current and duration. To a first approximation the value of this product remains unaltered over a comparatively wide range of surge current and corresponding maximum surge duration, in which damage to the tube does not occur.

Switching Circuits

There has recently been an extensive development of the use of gas discharge devices in the field of light current engineering and particularly that of communications. Here the cold cathode triode tube finds many applications and is proving a satisfactory and sturdy substitute for electromagnetic relays and contactors, with special advantages where the saving of space and high speed are important. The response time of a cold cathode triode can, under proper working conditions, be as little as 10 to 20 microseconds, whereas even the lightest high speed electromagnetic relay has a response one hundred times as long as this, and the normal kinds of relay are some ten times slower still.

The life and stability characteristics of the electric discharge device have been shown to be entirely adequate. When proper precautions are taken to relate the working current of the triode to its designed characteristic, lives of 10,000 hours continuous operation are not uncommon, and, if the duty cycle is low, the useful service of the tube may extend to decades. Since no thermionic heater current is required, the device consumes no power unless it is actually operating, and then it will respond to extremely small input pulses and almost any shape of actuating voltage waveform. It is silent in operation and, since it usually displays a visible glow when conducting current, a visual check of the operation of large banks of tubes can be made quickly and easily. In some applications the visible glow is used as a visual indication in a coding or counting device.

The cold cathode triode normally has a glass envelope and looks like a miniature thermionic valve. It contains a comparatively large cathode, usually coated with barium or some other electron emissive material, and smaller anode and trigger electrodes. Its most important characteristics are uniformity of breakdown voltage between trigger and cathode and high current sensitivity. Careful attention in design to the electrode spacings, the activity of the cathode and the composition and pressure of the gas filling ensures that the characteristics are precise and remain substantially unaltered during life. Potentials are applied between anode and cathode, and trigger and cathode, some 10 per cent less than the free breakdown voltage of each gap. No conduction will then occur, but the application of a suitable voltage pulse to the trigger will produce ionisation which diffuses rapidly to the anode/cathode gap and induces the main conduction current. The voltage across this gap remains substantially constant over a wide range of tube current. The difference of voltage between the anode and the main voltage supply is then available to operate an electromagnetic relay or to supply a triggering impulse to further triodes.

When the main gap is conducting, the trigger loses control of the discharge and conduction is made to cease either by reducing the anode voltage below a critical value or by applying to the anode an externally derived inverse voltage pulse of sufficient magnitude and duration. The variations of this basic circuit practice are multitudinous, but the typical examples shown in Fig. 5 will illustrate the main principles involved. Fig. 5 (*a*) typifies the simple operating principles outlined above. Fig. 5 (*b*) shows one

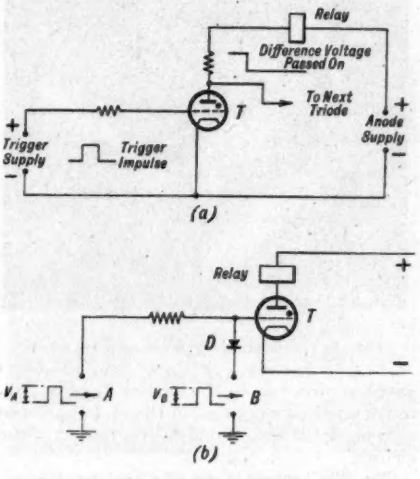


Fig. 5—Cold Cathode Triode Circuits

method by which voltage pulses from a common channel can be sorted electronically into specified subsidiary channels. In this circuit voltage pulses V_A or V_B appearing at different times will neither of them effect a breakdown of the main gap of triode T, since V_A will be effectively quenched in diode D and V_B will be prevented by the high reverse impedance of the diode from initiating the trigger discharge. If, however, pulses V_A and V_B are applied simultaneously, then diode D will not prevent V_A from actuating the trigger of triode T and the relay will operate. In effect, pulse V_A is "gated" by pulse V_B and if V_A is applied to a number of circuits of this type simultaneously it can be directed into any one of them by application of pulse V_B in the appropriate circuit.

The principle of the three-electrode triggered cold cathode tube has been extended to a multi-electrode form consisting essentially of a number of triodes (usually ten, but sometimes twelve), all mounted within the same envelope. The main application lies in counting circuits. Initially the cathode glow, visible through the end of the envelope, centres on the first of the series of ten cathodes, which are arranged in the form of a ring. The application of a split pulse to pairs of transfer electrodes mounted between the cathodes moves the glow to the next cathode. The tube thus becomes a digital counter, the visible glow rotating round and round the ring of cathodes. A voltage derived from the final stage in each rotation can be used to operate a second tube, counting tens, and this in turn will operate a third tube counting hundreds, and so on.

Applications to Radar Systems

Various types of three-electrode "trigger" tubes, often filled at pressures in excess of atmospheric, are used in the modulator circuits of pulsed magnetron transmitters. Their function is to control the charging and discharging of the high-tension pulse-shaping circuits associated with the magnetron valve.

Ingenious use is made of the gas discharge as a switching agent in various radar systems which have a common aerial for transmission and reception. The advantage of single aerial systems lies not only in a saving of bulk and weight but also in the avoidance of duplication of elaborate scanning mechanisms. It is by no means easy to maintain two highly directional moving aerials in exact mutual alignment throughout the scanning sequence. Means must be provided, however, when only one aerial is used, to protect the receiver from damage by the transmitter. The latter is generating a steady stream of powerful pulses of energy, each perhaps one microsecond in duration and spaced one millisecond from its predecessor. When these pulses pass along the aerial feeder, the receiver branch circuit must be closed to them. Within a few microseconds of the ending of each pulse, however, the receiver branch must be switched open to accept the minute pulses of energy which have been reflected back from the nearer objects in the radar beam. It is quite impossible to operate mechanical switches with the necessary speed, but various forms of gas discharge switch will open and close the circuit with efficiency and precision. These are known as TR (transmit-receive) switches and a somewhat similar device termed a TB (transmission blocker) switch is often used to carry out the allied duty of isolating the transmitter from the aerial during its quiescent period so that no received signal energy is dissipated uselessly in the transmitter itself.

Most radar systems operate at wavelengths of the order of 10cm or less, the transmitter

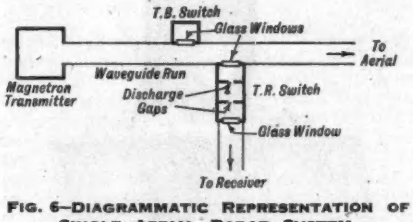


Fig. 6—Diagrammatic Representation of Single Aerial Radar System

and receiver equipment being connected to the aerial through waveguide systems (Fig. 6). The TR and TB switches are designed as resonant circuit elements containing a gas filling which remains unionised when their energy input is restricted to the level of the received signal. If the energy input is raised to correspond to the transmitting condition, ionisation of the gas filling occurs and the resonant element is then short-circuited by the discharge. The circuits can be arranged so that the receiver path will accept incoming signals through the TR switch with very little loss of energy in the reception period, but is closed to the transmitter pulse as soon as ionisation has built up in the switch. Similarly the TB switch is placed so that in its unionised state during the reception period the transmitter is effectively "blocked" from the receiver and presents a high impedance to incoming signals. When the transmitter pulse is generated, and the TB switch ionises,

the full transmitter power passes unhindered to the aerial.

A typical TR switch, associated with a transmitter generating pulses whose peak power exceeds 100kW, will restrict the power leaking through to the receiver to pulses whose total energy is well below 1 erg and whose power does not exceed 100mW. This distinction between energy content and power is made since, during each transmitter pulse, the initial stages of ionisation of the switch are accompanied by a "spike" of energy of extremely short duration passing through the switch, followed by a substantially steady state. The duration of the spike is difficult to measure, but its energy content can be determined and is a criterion of the protection afforded to the "mixer" crystal valve placed in circuit behind the TR cell. The duration of the spike is probably of the order of 10^{-9} to 10^{-8} seconds and both the magnitude and the duration are kept to a minimum by the provision of an auxiliary d.c. discharge which supplies electrons and ionising radiation to keep the main discharge gap in a state of readiness to break down as rapidly as possible.

To ensure a rapid recovery of the switch from its ionised state to the quiescent condition in which efficient reception is possible, highly mobile free electrons must be removed quickly from the main gap when the transmitter pulse has ceased. To hasten this process, the gas filling usually contains a component efficient in attaching free electrons to the much less mobile heavy atoms. The most efficient practical agent for this purpose is water vapour, and the TR switches are therefore usually filled with a mixture of this vapour and one of the rare gases, such as argon. This combination allows recovery to an efficient condition for reception in a very

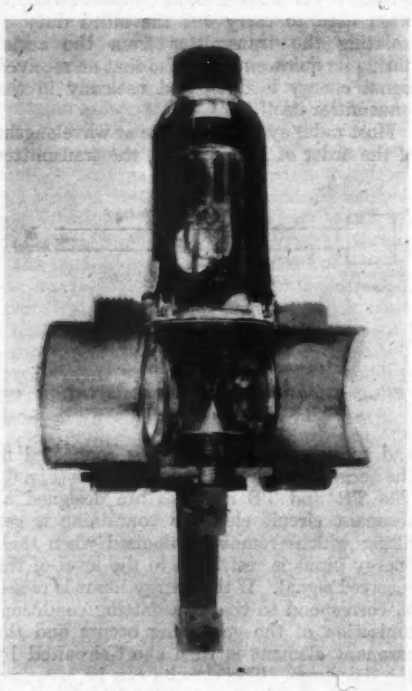


FIG. 7—SECTION OF TUNABLE "TR" CELL

few microseconds. Most types of TR switch have metal envelopes containing resonant circuit elements which include opposed conical electrodes between the points of which the main discharge occurs. One of the cones is usually hollow and contains the auxiliary electrode system which provides the d.c. "keep alive" discharge. This electrode system is coupled to the main gap through a small hole in the tip of the cone. Incoming energy pulses pass into the cell through a resonant glass window fused into the envelope and emerge through a second window at the other end of the cell to pass into the mixer system of the receiver. The early forms of switch (Fig. 7) contained a single pair of conical electrodes whose spacing could be varied by a mechanical device to bring the system to resonance with the transmitter. Later types of switch embody two such resonant elements with fixed gaps between the cones. In these switches the four resonant elements (i.e., the two windows and the two cone systems) are spaced a quarter of the waveguide wavelength apart and are designed to provide an overall band-pass characteristic which covers the range of frequencies used in the transmitter. In both types of switch a discharge is excited on the

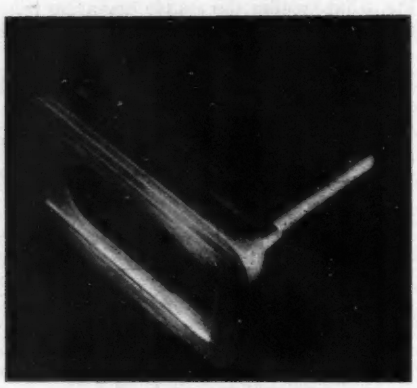


FIG. 8—TRANSMITTER BLOCKER SWITCH

entry window face by the high-power radio frequency pulses as well as in the main gap, and this contributes to the protective effect of the switch.

The TB switch is simpler and usually includes a single resonant window element in one wall of the metal envelope (Fig. 8), the opposing wall being spaced one-quarter of the waveguide wavelength distant. No conical electrode system is needed, since the discharge appearing on the window face under conditions of high input energy is sufficient to produce the switching effect required.

Other TR and TB systems are known in which the switching action is provided by placing an electrodeless discharge tube of pencil-like shape across the poles of a resonant diaphragm built into the waveguide system. The switch operates when the incident radio frequency energy excites a discharge within the tube and thus short-circuits the resonant system. Rapid recovery of the switch for reception is obtained by filling the discharge space with fragments of glass or quartz. The discharge is thus broken into many unit cells of small volume, in each of which the area of wall is large in comparison with the linear dimensions of the cell. Electrons and ions diffuse rapidly to the walls of these cells and recombine there when the discharge ceases.

Systems have also been devised in which discharge tubes akin to TR switches in design have been used to provide variable attenuation in a waveguide system. The principle usually employed is to couple the auxiliary "keep alive" discharge closely to the main gap and control the damping effect exerted on the resonant system by varying the d.c. current in this auxiliary discharge.

It is perhaps in these applications to microwave circuit techniques that the most ingenious uses of gas discharge switching are made. Those engineers who are more familiar with the use of discharge tubes at normal supply frequencies may well find the behaviour of the electric discharge somewhat surprising in applications where frequencies are measured in megacycles per second. The very rapid short-circuiting action of the switch can be induced by the formation of a discharge between electrodes which are themselves in direct metallic contact. Alternatively, it may be derived from the production of a discharge in an electrodeless tube buried in a metal box, or across a window pane in a metal plate. The potentialities of these devices are undoubtedly only partially explored at megacycle frequencies, and new applications will be found as research and development continues.

S.S. "Kenya Castle"

THE third one-class passenger liner to join the fleet of the Union Castle Line, the S.S. "Kenya Castle," sailed on her maiden voyage on March 31st. Prior to commencing her first voyage on the round Africa service of the company, the ship sailed on a short cruise to Spain, Portugal and North Africa. Built by Harland and Wolff, Ltd., the vessel is finely modelled and is of pleasing appearance. She has two masts and a single low streamlined funnel and four steel decks, and is a sister ship to the S.S. "Rhodesia Castle," which made her maiden voyage in October of last year. There are single, two, three and four-berth cabins for 530 passengers, who have accommodation equal to the cabin class of the mail ships, and all of whom share the amenities of the comfortable public rooms, including lounge, smoke-room, club-room, gallery library and an air-conditioned dining saloon, which has a seating capacity of 280.

The principal dimensions of the "Kenya Castle" are: length between perpendiculars 540ft by 74ft breadth moulded by 35ft 6in depth moulded, and a gross tonnage of 17,041 tons. Two sets of Parsons triple expansion, double reduction geared turbines, constructed by the shipbuilders, develop a total normal ahead power of 12,000 s.h.p. and drive three-bladed manganese bronze propellers to give the ship a service speed of 17·5 knots. Steam is supplied at a working pressure of 450 lb per square inch and a total temperature of 750 deg. Fah., by three Babcock and Wilcox oil-fired water-tube boilers, each incorporating a Howden-Ljungstrom regenerative air preheater, and working under Howden's forced and induced draught system. Saturated steam for the hotel services is supplied by two Cochran auxiliary boilers. The electrical load amounts to 3550kW and this is provided by two self-contained 750kW turbo generators and three 450kW diesel generators, all of which are situated in the engine-room aft of the main turbines. For emergency use there is a 75kW diesel generator which will supply power to the steering gear and essential services. There are five cargo holds, two forward and three aft of the machinery spaces, and some of the cargo 'tween decks are insulated. The derricks serving the hatchways include one for a 30-ton lift, and all are operated by electric winches.

AERIAL SURVEY OF CEYLON.—The Ceylon Government has awarded an aerial survey contract to Hunting Aerosurveys, Ltd., of London, for aerial photography in connection with the development of the resources of the island. This contract is a practical outcome of the technical assistance provided by the Colombo Plan. The work will include the photography of several areas of the island and will be used to assist in the forestry, irrigation and town planning departments in the development of their plans. Some of the photographs will later be used for preparing accurate contoured maps. The survey party will be equipped with the Percival "Survey Prince," a twin-engined aircraft specially designed for photography.

The Physical Society Exhibition

No. I

THE thirty-sixth annual exhibition of scientific instruments and apparatus, organised by the Physical Society, was opened at Imperial College yesterday, April 3rd, by Professor L. F. Bates, President of the Physical Society. Following the practice introduced last year, when there were 137 exhibitors, use is being made of the college main building in Imperial Institute Road and the Huxley Building in Exhibition Road, to accommodate this year's total of 142 exhibitors.

Besides the exhibition, and in association with it, two discourses have been arranged: to-day, April 4th, at 6.45 p.m., Mr. B. N. Wallis will speak on "Engineering Supersonic Aerodynamics" and at the same hour on Monday, April 7th, Mr. E. R. Davies will speak on "The Physical Basis of Colour Photography." Admission to the exhibition, which remains open daily, except Sunday, until Tuesday, April 8th, is by ticket only.

Although many of the exhibits are of interest mainly to those who are concerned with scientific laboratory work there are many others (and the number appears to grow year by year) which are likely to have a wider appeal to industry generally and to engineering in particular.

Some of the exhibits that are likely to be of interest to engineers are described briefly in the following paragraphs.

G.E.C. Research Laboratories

An interesting point about the high temperature furnace shown by the research laboratories of the General Electric Company, Ltd., is that its heating element is machined from a thin-walled graphite tube. The furnace holds a cylindrical charge approximately 6in high and 5in in diameter and is mounted on a 350 litre per second pump, which makes it suitable for many metallurgical treatments either in high vacuum or inert atmosphere. With the maximum power input of 6kW the furnace is capable

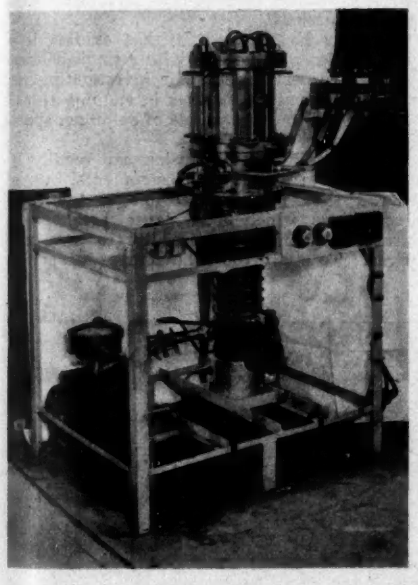


FIG. 1—HIGH TEMPERATURE VACUUM FURNACE—G.E.C.

of reaching temperatures in the region of 2000 deg. Cent. within twelve to fifteen minutes of switching on. Hence it is suitable for processes of quite short duration as well as those requiring prolonged treatment.

The heater of the furnace has been designed for three-phase working so that its current rating is kept as low as possible. Also, since the electrical connections serve as supports for the heater, three-phase working gives it better support and greater rigidity than would be possible with only two supports. The heater element (Fig. 2) is machined from a thin-walled graphite tube and, to increase its effective resistance, it is traversed by saw-cuts alternately from top and bottom. At the lower edge of the heater and integral with it there are three equi-spaced legs, which are dowelled and cemented to graphite plinths already bolted to three water-cooled copper lead-ins. These legs are the delta connections to the heater and are shaped to give a correct balance between electrical loss in the supports and heat loss conduction from the element.

The high temperature zone of the furnace is encased by molybdenum radiation baffles,

FIG. 2—THREE-PHASE CARBON HEATER ELEMENT OF FURNACE—G.E.C.

which limit the radiation loss from the heater, reducing this loss by 85 per cent, even though quite large spaces have to be left in the screening for pyrometry and to enable a high pumping speed to be obtained. Some idea of the performance of the apparatus can be obtained from the following table.

Temperature (Deg. Cent.)	Power (kW)
1100	1·0
1400	2·0
1760	4·0
2020	6·0

The general arrangement of the furnace is shown in Fig. 1.

The furnace body is of brass and copper and is water-cooled. Neoprene "O" ring gaskets are used to provide the vacuum seal at the junctions of the separate parts. The bottom flange of the outer casing seals directly to the baffle valve of a 350 litre-per-second oil diffusion pump. The effective pumping speed of the furnace is therefore quite high, even under vacuum, and it is quite easy to maintain pressures well below 0·1 micron of mercury.

The G.E.C. research laboratories are also showing an instrument for measuring the variation in diameter of machine drawn glass tubing. This instrument was designed to comply with the following requirements: to measure the changes in any diameter in the range 15mm to 40mm, to measure changes of 0·1mm over a range ±2mm, to record such changes continuously and allow for sudden increases in diameter outside the normal working range, to follow the tubing during its passage over the rollers and to accommodate breaks which occur occasionally during the process of manufacture.

The glass tubing is made to pass between two anodised aluminium rollers (Fig. 3), each roller being mounted on a movable plate. Two detector coils are attached to one plate and an armature to the other, the armature being arranged to move between the coils when the two rollers move relative to each other. The movable plates are spring-loaded together, so that the rollers are always in intimate contact with the glass tubing. Any variation in the tubing diameter gives rise to a relative movement between the roller plates and hence between the armature and the detector coils. This movement changes the out-of-balance current of a bridge, of which these coils form two arms. The out-of-balance current is rectified, amplified by means of a magnetic amplifier, and fed into a recording instrument.

Provision is made for altering the relative position of the armature with respect to the plate on which it is mounted, by means of an adjusting knob, so that the different sizes of tubing can be handled. The nominal diameter of the tubing to be measured is indicated on a scale plate and a pointer may be moved to any desired position on the scale by rotating the knob. Each position of the pointer then gives the nominal diameter of the tubing in terms of the mean distance between the rollers.

The diameter of the tubing between the rollers may suddenly increase sufficiently to cause the armature to come in contact with the inner detector coil. If this occurs any further movement of the armature in this direction causes springs on the guide rods holding the

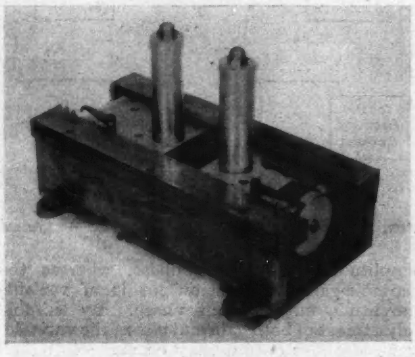


FIG. 3—CONTINUOUS GAUGING OF MACHINE DRAWN GLASS TUBING—G.E.C.

armature to be compressed, so that possible damage to the tubing is avoided. If the tubing should move sideways while passing between the rollers, the whole arrangement, including the rollers and the movable plates on which they are mounted, will move in the same direction as the tubing. This ensures that no spurious indications of variation in diameter are obtained. Any vertical movement of the tubing is also accommodated, in this case by the height of the rollers themselves. Finally, should a break occur in the tubing, the rollers may be moved sideways and held away from the glass by catches passed over pins in the main frame.

The Plessey Company, Ltd.

The Nyquist diagram plotter exhibited by The Plessey Company, Ltd., Ilford, Essex, is designed as a simple piece of apparatus capable of being used by comparatively unskilled people for the routine testing of production servo components. Briefly the function of the plotter is to make a polar plot of the locus of the vector, which represents, in amplitude and phase, the transmission of the servo apparatus under test. When the applied test frequency is varied from zero to infinity the end of the vector traces a curve, which forms the Nyquist diagram. Then, provided that the plotter embodies some means of indicating the frequency to which any point on the curve corresponds, the plotter can be used in the development and production of a servo mechanism, to find the response of the system or its com-

ponent parts to sine waves of various frequencies.

The block diagram (Fig. 4) shows the principle of operation of the plotter. An oscillator provides a variable frequency signal to drive the apparatus under test, the rate at which the frequency is varied being automatically adjusted to suit the prevailing conditions. A second output from the oscillator feeds a phase-shifter, which is mechanically coupled to the turntable on which a polar chart is carried. The output from the apparatus under test returns to the plotter and passes through a variable-gain amplifier, whose gain-control is mechanically coupled to a pen which moves radially over the chart. For a given oscillator frequency the phase-shifter output is of constant

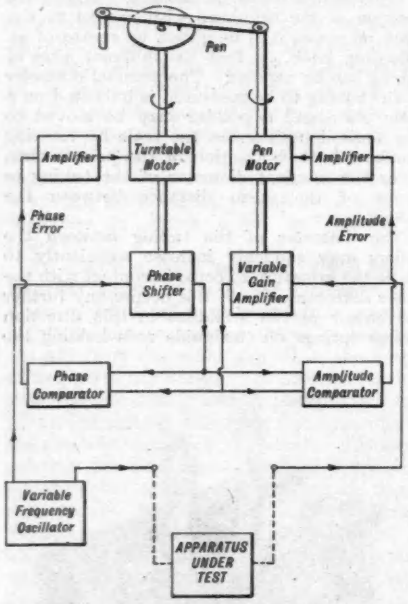


FIG. 4—NYQUIST DIAGRAM PLOTTER—PLESSEY

amplitude but variable phase, whereas the variable-gain amplifier output is of variable amplitude but constant phase. By suitable adjustment of both gain and phase, the variable-gain amplifier output may be made to match exactly the phase-shifter output. These adjustments are automatically carried out by two motors, which are fed with signals proportional to the amplitude difference, and phase difference respectively; in making the adjustments the motors also position the pen at the correct point on the chart.

At regular frequency intervals the frequency-sweep stops, and by means of a third motor the pen automatically writes a small arrow-head mark by which those points on the chart, corresponding to a known series of frequencies, can afterwards be identified.

The maximum oscillator sweep covers the range from 0·16 c/s to 1600 c/s (1 to 10,000 radians per second angular frequency) and any decade or decades within this range may be selected by switches. The higher frequencies will probably not be encountered in servo systems as such, but they may be uesful for investigating the stability of servo amplifiers which contain their own feedback loops. It is also possible that the wide frequency coverage may extend the usefulness of the plotter beyond the field of servo-mechanisms; the instrument can, of course, be applied to any device having an electrical input and output.

According to the provisional specification of the plotter, it covers a frequency range of 0·16 c/s to 1600 c/s; the oscillator output is 15V maximum; the source impedance is 500 ohms and the input impedance 250,000 ohms, and the amplitude range is approximately 30 to 1. The complete apparatus is housed in two units each measuring 22in by 12in by 12in.

KELVIN AND HUGHES, LTD.

To meet an increasing demand for a tide gauge which can be installed in remote coastal areas in order to obtain recordings during a hydrographic survey of that area, Kelvin and Hughes (Marine), Ltd., Barkingside, Essex, has designed a portable pressure operated

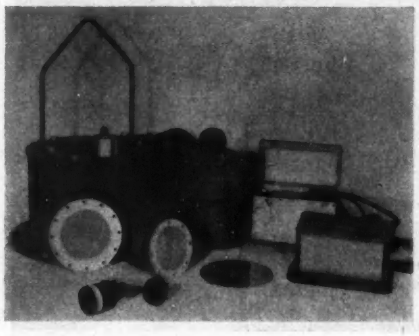


FIG. 6—PRESSURE OPERATED TIDE GAUGE—KELVIN AND HUGHES

mechanism which transmits, via a cable, to a recorder, the variations in pressure of the head of water above the instrument. Two versions are at present available for recording changes in water level up to 22·5ft and 45ft respectively, measured with a practical accuracy of 3in to 6in, when corrections are made according to the calibration chart which is supplied with each instrument. The time scale is 3in per day, the tide scales are 1in=7·5ft and 1in=15ft. The maximum depth of water in which the instrument can be placed is 100ft at low water.

The instrument (Fig. 6) consists of a steel tank with four stabilising legs supporting a pressure chamber, which has a rubber diaphragm protected by gauze and a metal plate and a number of holes drilled in it. Behind the rubber diaphragm is a compartment filled with distilled water and behind this is another compartment which is air filled. In the second compartment is a "Desynn" transmitter mechanism having the inside of its bellows open to the water-filled compartment and the outside of the bellows open to the air of the second compartment. By means of an air valve the pressure in the air compartment can be raised by a hand or foot operated pump to compensate for the static head of water in

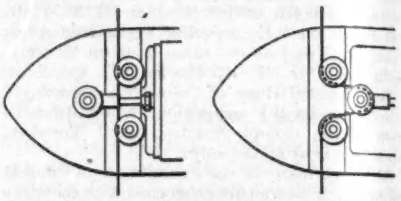


FIG. 7—YARN TENSION PICK-UP HEAD—KELVIN AND HUGHES

which the gauge will be submerged. An electric cable is brought out from the "Desynn" transmitter through glass seals from the water-tight gland and then taken round a bollard, to remove any strain on the cable at the gland.

Ashore, at the recording station, is a "Desynn" receiver motor, which is linked to a bimetallic stylus arm: an iridium-tipped pen makes contact periodically on to the "Teledeltos" paper drawn over rollers under the action of a seven-day clock mechanism. Barometric compensation is automatically applied through linkage to the stylus arm. A small buzzer is incorporated which operates periodically, giving the whole movement a slight vibration. This ensures free movement of all bearings. The equipment, with its associated power unit, operates from a 12V car-type battery and can be left unattended for long periods.

Another Kelvin and Hughes exhibit is a yarn tension pick-up unit with a single-channel strain recorder (Fig. 5) for investigating the rapidly fluctuating tensions in running thread and yarn during operations of spinning, spooling, weaving, &c.

The mean value of tension can readily be measured on simple dial instruments, but, of course, they take no account of the rapid fluctuations which may cause breakage or structural damage, especially to synthetic yarns. To study the behaviour of a machine,

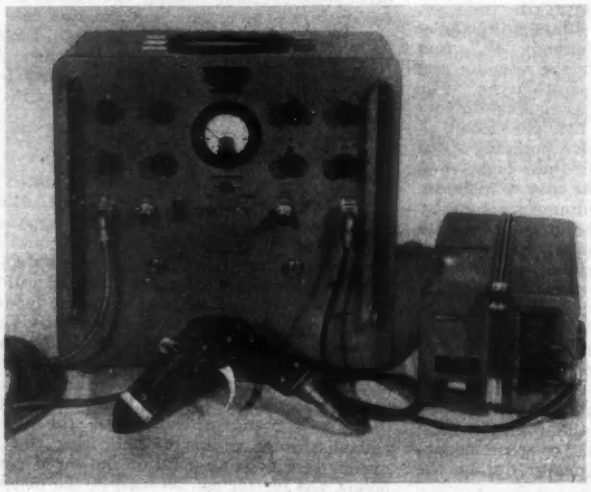


FIG. 5—YARN TENSION PICK-UP AND STRAIN RECORDER—KELVIN AND HUGHES

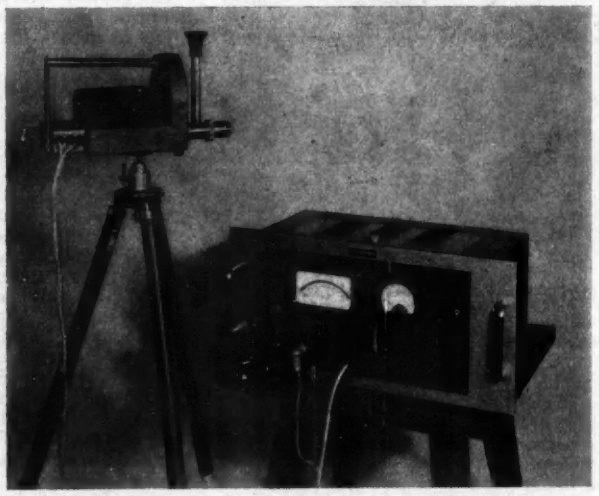


FIG. 8—RADIATION PYROMETER WITH LEAD SULPHIDE CELL—B.T.H.

or to adjust it for optimum performance in respect of tension fluctuations, an instantaneous graphic record of the fluctuations is required, and the pick-up attachment exhibited has been designed to enable the Kelvin Hughes single-channel strain recorder to be used for this purpose.

The tension pick-up unit consists fundamentally of a small cylindrical transducer of the inductance (variable-reluctance) type in which an armature is suspended by spring diaphragms between a pair of coils; a small movement of the armature then causes an increase in the inductance of one coil and a corresponding decrease in the other.

The yarn runs on a miniature ball-bearing pulley (Fig. 7) connected mechanically to the armature and round two guide-pulleys fixed to the frame so that the force on the armature is twice the tension in the yarn. The movement of the armature and hence the change in inductance is then proportional to the tension. This change of inductance is then converted by the strain recording amplifier into deflections of a stylus which draws a dry instantaneous and permanent record of the tension variations in the form of a fine black trace on "Teledeltos" paper.

The cylindrical inductance unit is mounted on a pistol-grip handle with a smooth exterior, which can be used in most places in winding and spinning machines and may be inserted between the warps of a loom. To load the yarn, a trigger is provided which moves the inductance unit forward; the yarn is then laid in a straight run between the pulleys and the trigger is allowed to spring back to the operating position. Only about $\frac{1}{16}$in pullout of yarn is required and there is no need to stop the machine for loading.

In its standard form the instrument has a maximum sensitivity of about 2 grammes for full-scale deflection and tensions up to 150 grammes can be accommodated simply by using the sensitivity control on the amplifier. The response of the equipment is uniform up to 60 c/s (i.e., 3600 r.p.m.), whilst the pick-up has a natural frequency of several times this for value and is substantially damped so that transient fluctuations of tension are faithfully recorded.

An advantage of this method of tension recording is that the pick-up unit is separate from the remainder of the equipment though connected to it by a cable of any length up to 50ft. The recorder can, if desired, be fitted with an additional fixed marker pen energised by a contactor clamped to the machine under investigation. In this way a mark is made on the record for each revolution or oscillation of some component of the machine and correlation may be observed between these movements and the changes in tension.

The equipment, in conjunction with some means for applying a constant rate of extension, can also be used for rapidly obtaining load-extension curves for fibres.

In addition, terminals are available into which voltage signals can be fed; the sensitivity at these terminals is about 1V into 1 megohm for full deflection of the pen, that is 2cm each side of the centre-zero. The equipment operates from 100–250V, 50–60 c/s mains. Six paper speeds are available, from 0·25 to 10cm per second.

B.T.H. Research Laboratory

The exhibits displayed by the B.T.H. research laboratory, Rugby, include a radiation pyrometer (Fig. 8) embodying a lead sulphide photocell (type M1). It can be used to measure equivalent black-body temperature over the range 150 deg. to 500 deg. Cent., with an accuracy of within ±5 deg. Cent. The source area viewed is 5mm by 1mm at 15cm distance from the lens, rising to 10cm by 2cm at 150cm. Higher temperature ranges can be covered by the use of filters or stops limiting the area viewed to smaller values.

The cell is used, with a high-gain tuned amplifier, as detector in a photo-electric flicker photometer arrangement. As in many optical pyrometers a comparison lamp is adjusted until a photometric balance between it and the external source is indicated; the input to the lamp then gives by calibration a measure of the temperature. Alternatively the auxiliary lamp may be used to calibrate the instrument as a direct deflection pyrometer.

Lead sulphide photocells may be used to actuate relays in response to infra-red, either filtered light or low-temperature heat radiation. Unlike photo-emissive cells, the power controllable by lead sulphide cells can suffice to actuate a suitable relay without interposition of valve amplifiers. In the exhibit a

FIG. 9—OPTHALMIC MAGNET—B.T.H.

lead sulphide cell, with the aid of a single relay, lights a 100W lamp when the cell views a surface at below red heat.

On the same stand a ¼ h.p. squirrel-cage induction motor is shown running under water. Complete sealing of the windings against ingress of water has been achieved by insulating the stator with a modified polyester resin, which can be used either for casting or impregnating. These two operations have been carried out simultaneously to give solid impregnation of the coils with an additional resin sheath on the end windings. The absence of voids in the windings makes for good heat dissipation and cool running. This form of insulation has been designed particularly for stator units to be used in machine tools. For this duty protection of the end windings against mechanical damage and good resistance to cutting oils and swarf are required. The rotor is of cast aluminium.

Another B.T.H. exhibit consists of an opthalmic magnet (Fig. 9), designed for removing ferro-magnetic foreign bodies from the eye. Three "Permendur" poles of various shapes recommended by an eye surgeon are used, any one of which can be quickly inserted into the magnet. For this particular design of magnet in which there is no iron beyond the pole tip to concentrate flux, the shape of the yoke and pole is such as to give maximum attractive force on a soft iron particle 1in from the pole tip, together with economy of power and weight. At this distance the attractive force is twenty-four times the weight of the particle. The d.c. power input to the magnet is about 2kW and the weight is 15 lb.

Ferranti, Ltd.

Among the items of test equipment shown and demonstrated by Ferranti, Ltd., Hollinwood, Lancs, is the "Tesvac" (Fig. 10), a portable and safe source of high-voltage, high-frequency output, which can be used for vacuum testing and many other applications. The circuit is similar to the well-known Tesla circuit and includes a spark gap of adjustable length fitted with tungsten tipped electrodes. The output frequency, 4 Mc/s is unusually high for instruments of this kind and for this reason provides more efficient and less disruptive penetration through the walls of a vacuum system. In vacuum testing the exploring electrode is held close to the glass wall of the system (or, in a metal system, at some point with a glass indicator tube) and visual indications are thereby provided which make it possible for the approximate pressure to be estimated. The instrument can often be used in the detection of small leaks in a glass vacuum system. On the application of the exploring head to the leakage point a bright

FIG. 10—"TESVAC" HIGH VOLTAGE TEST SET—FERRANTI

thread of light will appear to penetrate through the glass from the electrode and travel along the crack in the glass tubing. Another useful application is the removal of electrical leaks in vacuum tubes caused by "getter" deposit or evaporated metal, which may settle across mica or glass insulator supports. These leakage films can be removed or very much reduced by applying the discharge to the electric lead wires outside the tube, so giving rise to a track discharge along the leakage path inside the tube.

Metropolitan Vickers Electrical Company, Ltd.

Precision microwave test equipment including an oscillator, variable and fixed alternators, directional couplers, a standing wave detector, a variable short circuit, a dummy load and a microwave spectrometer with interchangeable units for X-band or S-band, are being shown by Metropolitan Vickers Electrical Company, Ltd., Trafford Park, Manchester, 7. This equipment is representative of a range of test gear which has been developed by the company for measurements in standard 3in by 1½in waveguide fitted with standard connectors.

One of these exhibits, a precision attenuator (type 501) is a dissipative attenuator, in which the attenuating element is a highly stable film of nickel chromium alloy bonded to a thin strip of hard glass. The resistive film is protected from corrosion and abrasion by a thin hard coating of magnesium fluoride. The element is supported in the waveguide parallel to the narrow side and may be moved across the guide from one wall to the centre. It is accurately located by its supporting mechanism and its position can be measured by a micrometer head. The waveguide section is built up from solid material to give accuracy of dimension and mechanical rigidity. The design of the glass vane and its support is such that the reflection of the incident wave by the attenuator is negligible, and the voltage standing wave ratio is greater than 0·96 over the wavelength range. The accuracy of the instrument is better than 0·02 db.

(To be continued)

Institution of Mechanical Engineers

ANNUAL REPORT OF THE COUNCIL FOR THE YEAR 1951

LAST Friday, at the Annual General Meeting, the Council of the Institution of Mechanical Engineers presented its report on the work and progress of the Institution during 1951. We print below some extracts from that report.

Retirement of Sir Henry Guy

The retirement of Sir Henry Guy, C.B.E., D.Sc., Wh.Ex., F.R.S., from the secretaryship, owing to ill health, had been announced in the previous autumn and took effect in January. At the Special General Meeting on January 19th, tribute was paid to the outstanding services he had rendered to the Institution in so many ways.

Appointment of New Secretary

On January 19th, the Council nominated Mr. Brian G. Robbins, M.Sc., (Eng)., A.C.G.I., M.I.Mech.E., as secretary, and he was duly appointed by the membership at the Special General Meeting on that date.

Conference of Representatives from the Engineering Societies of Western Europe and the United States of America

At the invitation of the Koninklijk Instituut van Ingenieurs, a second meeting of the Conference of representatives from the Engineering Societies of Western Europe and the United States of America was held at the Headquarters of the Koninklijk Instituut van Ingenieurs at The Hague from September 17th to 21st. Our own Institution was represented by the president, Mr. A. C. Hartley, C.B.E., B.Sc.(Eng.), M.I.Mech.E., and the secretary, Mr. Brian G. Robbins, M.Sc. (Eng.), M.I.Mech.E. The Institution of Civil Engineers and the Institution of Electrical Engineers were represented by their respective presidents and secretaries, and also present were representatives of certain Engineering Institutions of Belgium, Denmark, Finland, France, Holland, Norway, Sweden, Switzerland, and the United States of America.

Joint Engineering Conference

The Joint Engineering Conference arranged by the Institution of Civil Engineers, the Institution of Mechanical Engineers, and the Institution of Electrical Engineers, was held in London from June 4th to 15th, and was opened by the Rt. Hon. R. R. Stokes, M.C., M.P., B.A., M.I.Mech.E., Lord Privy Seal, in the unavoidable absence through indisposition of the Lord President of the Council, Lord Addison.

Technical sessions were held in the Meeting Halls of the three Institutions during the mornings and some afternoons of the period of the Conference. Thirty-five papers were presented, which recorded the contributions to the advancement of civilisation made by the engineers and scientists of Great Britain during the past hundred years, and many distinguished overseas engineers supplemented the story in the discussions by putting into proper perspective the contributions of their own countries.

The various papers, with discussions, are being printed in eleven separate parts, as follows:—

Part 1: General Report; Part 2: Railways; Part 3: Sea Transport; Part 4: Power; Part 5: Aviation; Part 6: Education and Training; Part 7: Road Transport; Part 8: Telecommunications; Part 9: Public Health; Part 10: Gasworks, Steel Works, Mining; Part 11: Electrical Measurement, Television, Gas Pressure, Cables, Lighting.

The interdependence of all branches of engineering and the co-operation of the members of the three major engineering Institutions in Great Britain were emphasised at the Conference, which was attended by 1000 member accompanied by 425 ladies. Many members of the Institutions and Societies participating in the Conference of Commonwealth Engineering Institutions, and the Conference of the Engineering Societies of Western Europe and the United States of America were included.

In addition to the technical sessions, a programme of visits to works and other places of interest was arranged on four afternoons during the Conference, and members and ladies also took the opportunity of visiting the South Bank Exhibition of the Festival of Britain.

The president held a reception and conversazione in the Geological and Science Museums on Tuesday June 5th, which was attended by about one thousand guests, and was enjoyed very much by all those present.

The Institution of Electrical Engineers arranged a Garden Party, and the Institution of Civil Engineers held their annual Conversazione during the period of the Conference.

The address at the closing session of the Conference was given by the Rt. Hon. Lord Reith of Stonehaven.

On the evening of Friday, June 15th, a Dinner was held for members of the Conference in the Connaught Rooms.

General Discussion on Heat Transfer

The Conference for a General Discussion on Heat Transfer, arranged jointly by the Institution and the American Society of Mechanical Engineers in co-operation with a large number of kindred societies in Britain, the British Commonwealth and Europe, was held at the Institution on September 11th to 13th, and was continued at Atlantic City, New Jersey, U.S.A., on November 26th to 28th, on the occasion of the 1951 Annual Meeting of the American Society of Mechanical Engineers. Ninety-three papers were presented dealing with developments in the mechanism of transference of heat and in the design of apparatus relating thereto, and the subject matter for consideration was divided into five main group headings, as follows:—

(1) Heat transfer with change of state.

(2) Heat transfer between fluids and surfaces.

(3) Conduction in solids and fluids.

(4) Radiation, instrumentation, measurement techniques, and analogies.

(5) Special problems such as heat transfer in turbine blade cooling, in liquid metals, in gas turbines, and in piston engines, the mercury boiler, and so on.

The Conference in London was opened by the president, Mr. A. C. Hartley, C.B.E., B.Sc. (Eng.), M.I.Mech.E., on the morning of Tuesday, September 11th, when he was supported by Professor Allan P. Colburn, M.S., Ph.D., M.A.S.M.E., and Professor O. A. Saunders, M.A., D.Sc. (Eng.), M.I.Mech.E. (Member of Council), who were the respective chairmen of the Executive Committees of the American Society of Mechanical Engineers and of the the Institution, Sir Henry Guy, C.B.E., D.Sc., Wh.Ex., M.I.Mech.E., F.R.S., and Colonel C. E. Davies, M.A.S.M.E., M.I.Mech.E., secretary of the American Society of Mechanical Engineers.

Each of the technical sessions was conducted by joint chairmen; one reporter presented in abstract the European papers and another reporter presented the United States and Canadian papers; the major portion of each meeting was devoted to discussion.

After the opening of the Conference the first technical session was held, followed by the second session in the afternoon. On the Tuesday evening, a Reception and Conversazione was held at the Institution, and the guests were received by the president and Mrs. Hartley, and the Hon. William L. Batt, M.A.S.M.E., Hon. M.I.Mech.E. (past-president of the American Society of Mechanical Engineers), and Mrs. Batt.

Technical sessions were held on the morning and afternoon of Wednesday, September 12th, and in the evening a James Clayton Lecture was given by Professor Allan P. Colburn, Provost of the University of Delaware, Newark, U.S.A., on the subject of "Problems in Design and Research on Condensers of Vapours and Vapour Mixtures."

A technical session was held in the morning of Thursday, September 13th, and the closing technical session took place during the afternoon, when special points arising during the previous five technical sessions were discussed. In the evening, a dinner was held for those attending the Conference.

A total of 705 members and visitors registered for the Conference.

The bound volume of the *Proceedings* of the Conference (including discussions in London and in Atlantic City) will form a comprehensive and up-to-date treatise on the developments which have taken place during the past ten years, within the field of heat transfer covered by the papers.

Specialist Groups

The Specialist Groups had a successful year of meetings, and the discussions on the numerous papers presented were again sustained and lively. The Industrial Administration and Engineering Production Group had five meetings, the Hydraulics Group five, the Applied Mechanics Group four, the Steam Group three, and the Education Group two meetings.

During the year the Internal Combustion Engine Group was re-formed.

James Clayton Fund

The bequest under the will of the late Mr. James Clayton provides for the annual award of a prize, a lecture or lectures, and of fellowships bearing his name. The following particulars relate to the administration of the fund during the year.

Award of the 1950 *James Clayton Prize.*—The will provides that a sum not less than one-quarter of the annual income shall be awarded as a prize to a Member, Associate Member, Graduate, or Student who, in the opinion of the Council, has contributed most in the year to modern mechanical engineering science by way of research, invention, or experimental work; or by a treatise or paper on a modern mechanical engineering subject; or by originality in

Membership: The Numbers on the Register during 1951 *are shown in the following Tabulated Statement*

	Hon. M.	M.	A.M.	C.	Assoc.	G.	S.	Totals	
Totals at December 31, 1950	30	4,703	14,324	34	976	10,551	4,479		35,097
Elected	5	36	304	—	25	1,688	1,330		
Reinstated	—	1	3	—	—	5	3		
Transferred	—	136	761	—	7	726	—		
Total additions during 1951	5	173	1,068	—	32	2,419	1,333	+5,030	
Deceased	1	97	108	2	3	18	6		
Resigned	—	15	31	—	10	59	94		
Erased	—	3	31	—	21	41	92		
Elections voided	—	—	1	—	3	3	24		
Transferred	—	—	135	—	15	739	741		
Lapsed	—	—	—	—	—	28	157		
Total deductions during 1951	1	115	306	2	52	888	1,114	—2,478	
Net alterations during 1951	+4	+58	+762	—2	—20	+1,531	+219		+2,551
Totals at December 31, 1951	34	4,761	15,086	32	956	12,082	4,698		37,649

design; or by service to mechanical engineering.

The sum allocated for award by the Council for the purpose during 1951 amounted to £1450, and the Council decided that the prize be awarded to Sir Harry Ricardo, B.A., LL.D., Hon.M.I.Mech.E., F.R.S., for his contribution to the development of engineering science and practice by way of invention, design and research, communicated in part in lectures during 1950.

The prize was presented to Sir Harry Ricardo at a General Meeting on February 16, 1951, and was accompanied by a certificate bearing the Seal of the Institution.

James Clayton Lectures.—James Clayton Lectures were delivered by Air Commodore F. R. Banks, Dr. H. H. Blache and Professor Allan P. Colburn.

Awards under the James Clayton Bequest Fund.—In June, 1951, four new Clayton Fellowships, three new Clayton Grants, and four extensions of existing Clayton Fellowships were awarded under the terms of the James Clayton Bequest Fund. The awards amounted in all to more than £3800. The names of the recipients and their schemes of work are set out below.

Clayton Fellowships.—B. E. L. Deckker, B.Sc. (Eng.), G.I.Mech.E., Research at Birmingham University on wave action occurring in the exhaust pipe of a two-cycle oil engine, with special reference to the scavenging process; D. Howe, G.I.Mech.E., Research at the College of Aeronautics, Cranfield, on stresses in swept-back aeroplane wings; H. Naylor, B.Sc., (Eng.), G.I.Mech.E., Research at Leeds University on lubrication in wire drawing; M. Ruddick, B.Sc., (Eng.), G.I.Mech.E., Research at Queen Mary College, London, on heat transfer to boiling liquids under conditions to be found in the cooling of gas turbine blades.

Clayton Grants.—J. Huddart, A.M.I.Mech.E. To take a graduate course of study at Birmingham University on high amplitude pulse transmission, with special reference to the internal combustion exhaust system; D. R. S. Rabley, B.Sc. (Eng.), A.M.I.Mech.E. For post-graduate study in photo-elastic methods; N. D. Thomson, B.Sc. (Eng.), G.I.Mech.E. To carry out a tour of observation of British and Continental steel works and rolling mills.

Extensions of Existing Clayton Fellowships.—J. Halling, B.Sc., (Eng.), G.I.Mech.E. Research at the Imperial College, London, on rolling friction; with special reference to surface finish and applied loading; J. Houghton, B.Sc. (Eng.), G.I.Mech.E. Research at Queen Mary College, London, on the effect of end constraint on thin walled and solid cylinders of hyperbolic aerofoil shape subject to torque, with special reference to turbine blades; G. Moss, B.Sc. (Eng.), G.I.Mech.E. Research at King's College, London, on the development of a continuous filter and a theoretical investigation of the laws of filtration; F. Ellis, B.Sc., G.I.Mech.E. Research at the Imperial College, London, on hot and cold rolling.

Researches by Clayton Fellows, or by those receiving Clayton Grants, in Progress or Completed During the Year:—

Imperial College of Science and Technology.—Investigations are in progress on a method of jet propulsion for marine application; on rolling friction and on the measurement of strains in hot and cold rolling by special methods.

Manchester College of Technology.—A research is approaching completion on the measurement of boiler flue temperatures.

King's College, London.—A research has been completed on the combustion of oil fuels and another is in progress on filtration practice and theory.

Birmingham University.—A research is approaching completion on the flow characteristics of poppet valves.

Queen Mary College.—A research on the effect of end constraint in thin walled cylinders of aerofoil shape is approaching completion.

Gravesend Technical College.—Experiments are approaching completion upon a method of damping out unwanted vibrations in an automobile which are transmitted from the road to the chassis.

Inventions and Research

Pipe Flanges Research Committee.—Progress is being made in the revision of the British Standard Specification for steam pipes for use with high temperatures and high pressures, and it is expected that the issue of the Committee's third report will be made during 1952.

King's College, London.—Work is proceeding on the small-scale differential analyser, and the machine is being run for purposes of test and adjustment, in connection with which a number of simple differential equations have been solved.

The main difficulties so far encountered arise from imperfections in the commercially-produced gear wheels used, but it is expected that careful running-in will eliminate these imperfections.

Leeds University.—The work on helical torsion springs, extended to cover a considerable range of wire sizes of B.S.S.T.A. 3 material, has now been completed and design charts have been compiled incorporating the results of the whole investigation. It is hoped that permission will shortly be obtained from M.E.R.O., D.S.I.R., to submit this work for consideration by the Institution.

The work on shot peening has reached the stage where scatter band *S–N* curves, for both the shot-peened and plain conditions are available for mean stresses of 35 and 40 tons per square inch, and similar data are being produced for 30 tons per square inch mean stress, which will complete the useful range. It is hoped, when this is completed, to translate the results into practical spring design showing saving in material weight.

Manchester College of Technology.—A thesis on tool life, including the precision measurement of the crater, has been completed. Work on the fundamentals of metal cutting is being continued by two workers who have close contact with the work of the Mechanical Engineering Research Organisation. The work on tapping is to proceed. The general facilities for metal cutting research have been very considerably extended.

Royal Anthropological Institute.—Analyses and metallographic examination have continued on a number of ancient copper and bronze specimens. A valuable investigation was made concerning the method of manufacture of a prehistoric axe-hammer. This was found to have been cast from natural, or virgin, copper (see *Man*, October, 1951, No. 234). The production of a book, *Notes on the Prehistoric Metallurgy of Copper and Bronze* (Pitt Rivers Museum, University of Oxford, 1951), was greatly facilitated by the work of the Committee over the past few years.

Benevolent Fund

The Council draw attention to the work of the Benevolent Fund and do so with the confident hope that members will continue their generous support of this worthy cause. Members who are not already subscribers to the Fund are asked to join and in that way help the Committee of Management in the work they undertake for the Fund during the year. During 1951, a sum amounting to £7307 was granted to seventy-five cases. As the Institution bears the cost of administering the Fund, practically the whole of each subscription received is applied to the allowances and grants. In connection with the latter, the Committee of Management have been able to assist with the education of the children of deceased members.

H. Stacey Cattermole Trust Fund.—The Committee of Management considered a number of applications and recommended to the Council the payment of grants to six cases. Particulars of the H. Stacey Cattermole Trust Fund will be found on page 13 of the Report.

Model Conditions of Contract

Attention is drawn to the availability by purchase of the revised Model Form of General Conditions of Contract (A) for use in connection with Home Contracts with Erection, suitable for the mechanical and electrical engineering industries. This Model Form, publication of which has been authorised by the Council and by the Councils of the Institution of Electrical Engineers and the Association of Consulting Engineers, can be purchased at the cost of 5s. per copy, including postage, on application to the secretary of either Institution or of the Association.

Centrifugal Pumps in Steam Power Stations*

By R. PENNINGTON, B.Sc. Tech., M.I.Mech.E.†

No. II—(*Concluded from page 434, March 28th*)

Boiler Feed Pumps

Pressure Characteristics of the Feed System.—The curves in Fig. 8 illustrate the pressures required by the feed system at various steam and water flow rates. The curves are based on a typical turbine stop valve pressure of 1500 lb per square inch. To this figure must be added the frictional losses of the steam in the pipework to the turbine and in the superheater as shown. This fixes the maximum boiler drum pressure for normal full-load steam rating of the boiler. If to this be added the losses through the economiser, feed regulator, and feed piping, and the static lift from feed pump to boiler drum, the pressure required at the feed pump outlet is obtained. Feed pump capacity is usually specified to be about 25 per cent in excess of boiler full load. Although average rates of steaming and feeding are equal over a period, there may be considerable divergence in the two rates at any given moment, and for that reason the feed pressure required for maximum steam rate follows curve *A*. Similarly, curve *B* represents the feed pressure required for minimum steam rate. Thus, normal operating conditions may require any pressure and output between these two lines. Under blow-off conditions there is a considerable rise in boiler drum pressure and the feed pressure required follows curve *C*, although it is usual to limit the pump output required under these conditions to suit approximately full load boiler rating.

There is a tendency to be over liberal in estimating the various losses in the system for normal operation, and this either involves the removal of pump stages or an unnecessary build-up of pressure in the system.

Pressure Characteristics of Feed Pumps: Constant Speed and Variable Speed.—In Fig. 9 the three curves *A*, *B* and *C* are transferred from Fig. 8, and represent the pressure output characteristics required by the feed system at the feed pump outlet. The pump must be capable of giving the overload quantity at normal maximum boiler drum pressure, duty point *D*, and not less than 100 per cent capacity at blow-off pressure, duty point *E*. In the example chosen, the feed pumping is in two stages and the pump characteristics are designed so that the curve for the outlet pressure from the second stage passes through these two points at constant speed as shown by *F*.

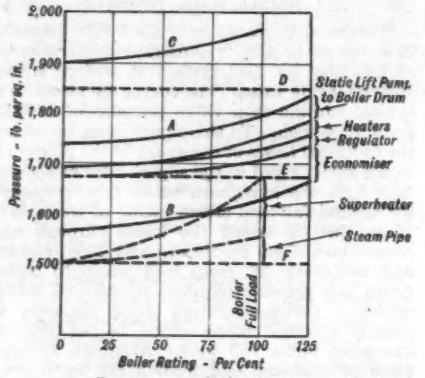
It will be noted that on reduced loads there is more pressure than is needed, due to the reduction in system requirements, the rise in the pump characteristic, and the need for meeting blow-off conditions. This excess pressure may make the operation of the boiler feed regulators erratic and involves a waste of power.

Speed control of the pump may be used to alleviate this problem. Where changes in load follow a fairly well-defined pattern, manual control of speed may give reasonably satisfactory results. With automatic control and the multiple system, where several pumps in parallel feed into a common header, the usual practice is to maintain a reasonably constant pressure at a suitable common point in the feed header, the pressure being selected to suit the maximum value required by the system as indicated by point *G*. This pressure is lower than pressure *E* by an amount equal

* Institution of Mechanical Engineers. March 21st Abstract.

† Director, Mather and Platt, Ltd., Manchester.

to the static lift between pump and header plus friction in heaters. There may be a slight rise in pressure with reduction in load (to suit the type of speed regulator used), so that the pressure at the pump outlet would be as shown by the almost horizontal curve *H* passing through point *E* and following the constant speed curve *F* between *E* and *D*. The pressure is still considerably in excess of the requirements of the system (between 10 and 25 per cent, in this instance, for loads up to 100 per cent), and it is doubtful if the savings in pressure and power achieved are worth the complications and expense involved, particularly as the rise in the pump pressure characteristic rarely exceeds 10 per cent. On the unit system the



——— Pressure required at pump outlet; *A*, normal maximum; *B*, minimum; *C*, blow-off.
— — — — Boiler drum pressure: *D*, blow-off; *E*, normal maximum; *F*, normal minimum; or turbine stop valve pressure.

FIG. 8—*Pressure Characteristics of Boiler Feed System*

pressure developed with variable speed pumps may follow very closely the characteristics of the feed system *A*, *B*, *C*, and under these conditions a stronger case can be made out for speed control. The shaded area between *A* and *B* shows the pressure output range under normal (non-blow-off) conditions, variable speed, unit system.

It will be noted that the second-stage pump operates at constant speed, and the speed control is effected on the first-stage pump. When operating at the minimum speed it is important to ensure that there is adequate pressure at inlet to the second-stage pump to prevent vaporisation. The minimum safe pressure is marked *J* on the curves.

Power Characteristics with Variable Speed.—Fig. 10 shows typical power characteristics based on the performance of the first-stage variable-speed feed pump (Fig. 9), multiple unit and single unit operation. The top group of curves is for the multiple system and curve *A* is the electrical horsepower input to the motor at constant speed. Curves *B* and B_1 are the ideal curves for maximum and minimum steam drum pressure conditions respectively, assuming the developed pressure closely follows the system characteristics. Curve *C* shows the electrical horsepower input when speed control

Notation

A_t	Atmospheric pressure.
C_a	Cavitation coefficient.
e	Pump efficiency.
H	Net total head.
h	Net head per stage.
h_a	Net available head, per stage.
h_{cm}	Cavitation margin.
h_{dp}	Depression head.
h_f	Friction losses before pump inlet.
h_g	Generated no-loss pressure head.
h_i	Absolute head at pump inlet.
h_l	Total hydraulic losses in pump.
h_s	Suction lift.
h_{st}	Static head over pump centre line.
L_i	Pump inlet size $= Q^{\frac{1}{2}}/h_{dp}^{\frac{1}{4}}$.
N	Pump speed, r.p.m.
n	Number of stages in pump.
P_{pi}	A dimensionless parameter $= V_i/U_i$.
Q	Output.
S_c	Speed coefficient in formula: $N_{max} = S_c h_{dp}^{\frac{3}{4}}/Q^{\frac{1}{2}}$.
S_h	Specific heat of liquid.
U_i	Peripheral velocity of the impeller eye.
V_i	Axial component of flow in impeller eye.
V_p	Vapour pressure.
W	Output, lb per hour.
X	Balance leakage, lb per minute.

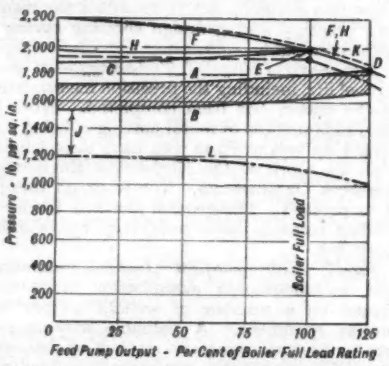
is by means of rotor resistance, and includes the additional losses in the motor which are approximately proportional to the speed reduction. Curve *D* is for hydraulic coupling control, and in addition to the power loss proportional to speed reduction (as for rotor resistance) there is a loss due to the initial slip of 2 to 3 per cent, plus coupling windage, so that the power absorbed at maximum output is actually increased. The two lower groups of curves are for the unit system, showing the comparative performances for both methods of speed control, and they indicate the increased economy that is possible with the unit system of operation. The power at constant speed is approximately equally divided between the first and second-stage units, so that the overall saving of power is only about half the amount shown. Under blow-off conditions curves *C* and *D* apply throughout.

Factors Influencing Choice of Speed for Boiler Feed Pumps, Motor Driven.—On a 50-cycle supply, motor-driven feed pumps operate at a speed of either 1500 r.p.m. or 3000 r.p.m. The main factors which determine which speed should be adopted are:—

(1) Relative efficiency.
(2) Maximum number of stages permitted in a single unit.
(3) Avoidance of cavitation.
(4) Initial cost.
(5) Maintenance.

In general, a pump at a speed of 1500 r.p.m. has a higher efficiency than one at 3000 r.p.m. for the same duty.

As far as possible it is desirable to avoid a series arrangement on account of the added



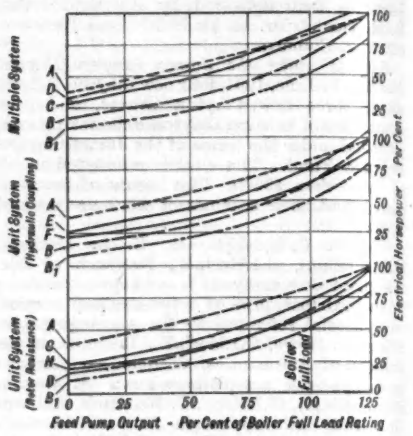
A, B, C Pressure required at feed pump outlet with various boiler conditions (see Fig. 8). Also, outlet pressure from second-stage feed pump, variable speed, unit system.
D Design duty point for feed pump at normal maximum boiler drum pressure *A*.
E Design duty point for feed pump at boiler blow-off pressure *C*.
F Outlet pressure from second-stage feed pump, constant speed.
G Controlled pressure in feed header, boiler full-load, variable-speed, multiple system.
H Outlet pressure from second-stage feed pump, variable-speed, multiple system.
J Minimum pressure at inlet to second-stage pump to avoid vaporisation.
K Generated pressure, combined first and second-stage feed pumps, constant speed.
L Generated pressure, second-stage pump, constant speed.
Shaded area shows pressure output range under normal conditions, variable speed, unit system.
— — — — Controlled pressure in feed header, variable speed, multiple system.

FIG. 9—*Pressure Characteristics of Feed Pump*

complications. The limiting factors for a single-unit pump are the relation between output and total head (the larger the output the fewer the stages for a given total head), speed and specific speed.

It is known that the head per stage, $h = (NQ^{\frac{1}{2}}/N_s)^{\frac{4}{3}}$ and therefore total head $H = n(NQ^{\frac{1}{2}}/N_s)^{\frac{4}{3}}$ where n is the number of stages. If the maximum permissible number of stages and the minimum specific speed are fixed, then the maximum total head for a single-unit pump is H = constant $(NQ^{\frac{1}{2}})^{\frac{4}{3}}$, and for a given speed H = constant $XQ^{\frac{4}{3}}$. If $n = 12$, $N_s = 750$, $N = 1500$, and Q is in I.G.P.M. the expression becomes $H = 30Q^{\frac{4}{3}}$ (Fig. 11, curve *A*). If the specified head is greater than the value of H obtained from this curve, it is necessary either to adopt a series arrangement at 1500 r.p.m., or use a pump at a speed of 3000 r.p.m. if conditions permit. Fig. 11 (curve *B*) shows the maximum permissible total head at 3000 r.p.m., the formula being $H = 76Q^{\frac{4}{3}}$.

Whatever the speed selected, it is essential that the available inlet head is sufficient to ensure freedom from cavitation. It has already been shown that the maximum speed is determined from the expression $N_{max} = S_c h_{dp}^{\frac{3}{4}}/Q^{\frac{1}{2}}$ and for boiler feed pumps the value of S_c can be taken from the curves in Fig. 12. The expression HS_g/e is a function of power absorbed, which affects the shaft and impeller boss diameters, and therefore the suction performance. If the ascertained value of N is greater than 3000, then the pump speed could be either



——— *A* Constant speed.
— — — *B* Variable speed, ideal, maximum drum pressure.
— · — · — B_1 Variable speed, ideal, minimum drum pressure.
——— *C* Variable speed, rotor resistance, multiple system.
——— *D* Variable speed, hydraulic coupling, multiple system.
——— *E* Variable speed, hydraulic coupling maximum drum pressure, unit system.
——— *F* Variable speed, hydraulic coupling, minimum drum pressure, unit system.
——— *G* Variable speed, rotor resistance, maximum drum pressure, unit system.
——— *H* Variable speed, rotor resistance, minimum drum pressure, unit system.

FIG. 10—*Feed Pump Power Characteristics with Variable Speed*

3000 r.p.m. or 1500 r.p.m., but if it lies between those figures, then the permissible speed is restricted to 1500 r.p.m. If it is desired to run at 3000 r.p.m., then the inlet head would have to be increased accordingly. The curves in Fig. 13 have been drawn to show the minimum recommended inlet head above vapour pressure for the two speeds 1500 r.p.m. and 3000 r.p.m. They are based on the relation $h_{dp} = (NQ^{\frac{1}{2}}/S_c)^{\frac{4}{3}}$, taking values of S_c from Fig. 12, using the curve for $P_{pi} = 0{\cdot}125$ and the appropriate value of HS_g/e.

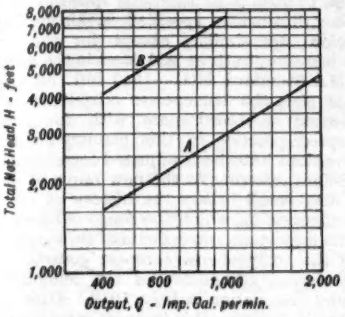
While the initial cost of a pump run at 3000 r.p.m. is lower than for one run at 1500 r.p.m., the maintenance costs on the pump of lower speed are likely to be less, on account of the low speed and the considerably reduced velocities resulting from the smaller head per stage.

Relative Merits of High-Temperature Feed Pumps and High-Pressure Heaters

There are two alternative systems in general use. One is to place the heaters after the feed pumps, so that the heaters are subject to the full discharge pressure while the feed pumps deal with water at medium temperature. The other is to place the pumps after the heaters, so that the pumps deal with high-temperature water while the heaters are subject to only moderate pressure.

For the feed pumps there need be no problem, as for many years past they have been in regular service on temperatures around 400 deg. Fah. and they have been equally satisfactory as pumps working on lower temperatures. If, therefore, there is reluctance to install high-pressure heaters, then high-temperature feed pumps provide the solution. However, with this arrangement it is necessary to divide the

feed pumping into two stages, the first stage providing sufficient pressure to obviate flashing on leaving the heaters and to avoid cavitation at inlet to the second-stage pump. Two-stage pumping therefore requires more floor space, more valves and piping, and control and operation are more complicated. On the other hand, pumps designed for medium temperature are of simpler construction, but the lower cost must



Number of stages, 12 ; specific speed, $N_s = 750$.
A 1500 r.p.m. B 3000 r.p.m.

FIG. 11—*Relation Between Output and Maximum Permissible Total Net Head for a Single-Unit Pump*

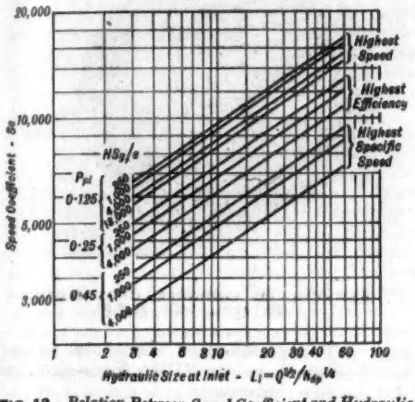
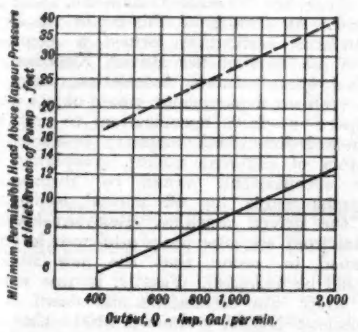


FIG. 12—*Relation Between Speed Coefficient and Hydraulic Size at Inlet*



Add vapour pressure to values shown to determine minimum absolute pressure required at inlet flange of pump.

Values of I.G.P.M. are for single-inlet impellers, for double-inlet impellers take half total output.

– – – – For generated pressures up to 2000 lb. per square inch at 3000 r.p.m.

——— For generated pressures up to 1250 lb per square inch at 1500 r.p.m.

FIG. 13—*Chart Showing Minimum Head Required at Pump Inlet Flange for Steady Conditions*

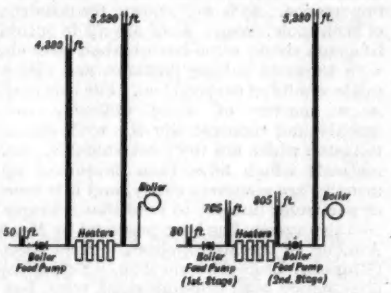
be weighed against the higher cost of high-pressure heaters.

Another important consideration to be taken into account in assessing the relative merits of the two arrangements is that high-temperature pumping in conjunction with medium-pressure heaters is less economical in fuel consumption than is the alternative scheme, independently of any difference in pump efficiency.

When water is fed into a boiler at a given weight rate and against a given pressure, the energy to be imparted to the water is inversely proportional to the specific gravity. So the higher the temperature of the feed water the greater the power required for boiler feeding and therefore the more important is the need for the most economical arrangement.

The energy is provided partly by the feed pumps and partly by the heaters. If the overall efficiencies (fuel/water) for pumps and heaters be taken approximately as 20 and 80 per cent respectively, it is apparent that greater economy is secured by making the heaters do as much of the work as possible. This can be achieved by arranging the pumps at the inlet, rather than the outlet, side of the heaters.

Fig. 14 shows the alternative arrangements *a* and *b*. In both schemes the weight rate of flow is constant at all points in the system, and



	Head, feet	Pressure, lb per sq in	Temperature, deg. Fah.
a	50	20	200
	4830	2020	200
	5380	2000	400
b	50	20	200
	765	320	200
	805	300	400
	5380	2000	400

FIG. 14—*Relative Operating Conditions for Two Alternative Feed Systems*

the water enters the system at 20 lb per square inch, 200 deg. Fah., and is discharged into the boiler header at 2000 lb per square inch, 400 deg. Fah., so that the work done on the water is the same. It follows that the work done between any two points is proportional to the difference in feet head as shown by the vertical columns in the diagram. (Except for 20 lb per square inch across the heaters, frictional losses in the system are neglected.)

The following figures show the comparative performances of the two schemes :—

Work to Water Per Pound of Feed Water, in Foot-Pounds

At 200 deg. Fah., 1 lb per square inch = 2·39ft. of water
At 400 deg. Fah., 1 lb per square inch = 2·69ft. of water.
Increase per 1 lb per square inch = 0·3ft of water.

Pump(s)	Heaters	Total
Scheme *a*		
(2000 × 2·39)	(2000 × 0·3)	5380ft-lb
= 4780	= 600	
(89 per cent)	(11 p.c.)	(100 p.c.)
Scheme *b*		
[(300 × 2·39) + (1700 × 2·69)]	(300 × 0·3)	
= 715 + 4575		
= 5290	= 90	5380ft-lb
(98·5 per cent)	(1·5 p.c.)	(100 p.c.)

Equivalent B.Th.U.s Required from Fuel Per Pound of Feed Water

Pump(s)	Heaters	Total
Scheme *a*		
$\frac{4780}{0·20 \times 778}$	$\frac{600}{0·80 \times 778}$	
= 30·70	= 0·97	31·67 B.Th.U.
Scheme *b*		
$\left(\frac{715}{0·20 \times 778} + \frac{4575}{0·20 \times 778}\right)$	$\frac{90}{0·80 \times 778}$	
= (4·60 + 29·40)		
= 34·0	= 0·15	34·15 B.Th.U.

In scheme *a* the feed pump raises the pressure to 2020 lb per square inch before the water passes through the heaters, and it will be noted that, in addition to raising the temperature, the heaters supply the energy equivalent to lifting the water from 4780ft to 5380ft (4780ft = 4830ft minus 50ft loss in heater). In scheme *b* two-stage pumping is required, the first stage supplying a pressure of 320 lb per square inch to prevent vaporisation of the water entering the second stage. The heaters supply only a small proportion of the energy to the water on account of the low pressure.

Thus boiler feeding scheme *b* requires 7½ per cent more fuel than does scheme *a*.

A Sheffield Firm's Centenary

THIS week, the Sheffield firm of Samuel Osborn and Co., Ltd., has reached its centenary. To mark the occasion, the company has produced an attractive little book, entitled *Pioneers for a Century*, which has been written by Mr. T. Alec Seed, and which presents a history of the firm's growth and achievements. It reveals also how the policies and the principles established by Samuel Osborn, the founder of the business, have been maintained.

Samuel Osborn was born at Banner Cross, Sheffield, in 1826, his father being a partner in the firm of Clark and Osborn, "merchants and manufacturers of pen- and pocket-knives, razors, brushes and tortoiseshell combs." Samuel was the third child of a family of five and, owing to his father's death at the age of thirty-two, it became necessary for him to find a job by the time he was fifteen. For a time, the young Samuel was employed in drapery establishments in Sheffield, but steel was a much greater attraction to him than soft goods, and when he was nineteen, he joined Thomas Ellin and Son, who made tools of various kinds. Subsequently, he went to Henry Rossell and Co., who produced files, saws and shear blades, with whom he remained until the end of 1851.

On April 1, 1852, Samuel Osborn, at the age of twenty-six, started his own business, as a manufacturer of files, renting premises at 180, Broad Lane, Sheffield. His first purchase of stock for making files amounted to £8 7s. 6d., and the first wages, paid on April 10, 1852, amounted to £2 15s. The establishment was known as Clyde Works, and in those early days, of course, all files were hand made. It is probable that, at first, the only operations performed in the works were the cutting of the steel bars, the forging, hardening—possibly in a blacksmith's fire—warehousing and dispatching. The cutting of the teeth and the grinding were done at the houses of the file cutters and at the grinding wheels in the valleys. It is recorded that transport was provided by a Mr. Loy, who was employed with a donkey and cart to ply between the works and Rivelin Valley. On Saturdays, however, he would use a trap instead of a donkey-cart, and take the manager's wife for a drive ! The business progressed, and in 1856, Samuel Osborn announced himself as a "steel converter and refiner," manufacturing "superior saws, tools, &c.," in addition to files. In that year he rented a six-hole crucible furnace in Carver Street, Sheffield, and a year later he had a furnace in Pea Croft and a tilt and forge in a district of Sheffield known as Philadelphia. From the first, Samuel Osborn took a great interest in the health and welfare of his workpeople; "grinders' asthma" caused by millstone grit and lead poisoning, resulting from the soft bed of lead in which the files were placed for cutting, were special risks to the elimination of which he gave particular attention. In 1864, Samuel Osborn discovered an amalgam which made a soft bed for file cutting and successfully replaced the lead bed. Then, despite considerable opposition from workpeople and other file makers, he acquired the rights to manufacture and use a file cutting machine invented by a Canadian named Weed, the employment of which reduced the physical contact of the workers with the "beds" to a minimum. A few years later, Samuel Osborn introduced machines for grinding files, which lessened the danger of "grinders' asthma."

Additional premises—known formerly as the Hartford Works—were acquired in 1868, and in 1871 the business became known as Samuel Osborn and Company. Just prior to that,

Samuel Osborn had met Robert Forester Mushet, a meeting which led to "R. Mushet's Special Steel" being developed and produced by the Osborn company. So rapidly did the company's activities increase thereby that, by the end of the nineteenth century, it was claimed that it held 50 per cent of the world's business in self-hardening tool steel. The acquisition of "R.M.S." steel meant fresh energy on Samuel Osborn's part. Increasing trade required the company to expend a great deal of money on new buildings and plant, a step which had to be taken at a time when materials and labour costs had risen, and at a time when fuel costs had increased considerably. In the year 1873—when Samuel Osborn was elected Master Cutler—his company was caught by the financial stringencies created by a trade recession in America. For some months, Samuel Osborn struggled valiantly to avoid disaster, but he had launched out beyond his immediate capital resources and early in 1874 he was compelled to file a petition for liquidation. From all quarters there came expressions of sympathy. On returning from the first meeting of his creditors, Samuel Osborn was met by a deputation from his workpeople, who offered to submit to a 5 per cent reduction in their wages for two years if he would continue the works. An arrangement with his creditors enabled recovery without having to take advantage of their offer. By 1884, Samuel Osborn had completed repayment of all outstanding debts and accumulated interest.

The business progressed. Before his death in 1891, Samuel Osborn's sons were taking part in its activities, and by 1893 the number of employees had reached 800. Additional premises, including a foundry, were purchased, and in 1905 the business became a private limited company, with William Fawcett Osborn, the founder's eldest son, as its chairman. He was elected Master Cutler in 1906. In the years that followed, S. Eric Osborn, the grandson of the founder, joined the firm, which continued to develop new tool steels, and which, among its other activities, took up the manufacture of tramway trackwork and railway buffers and coil springs. The business was converted into a public company in July, 1920.

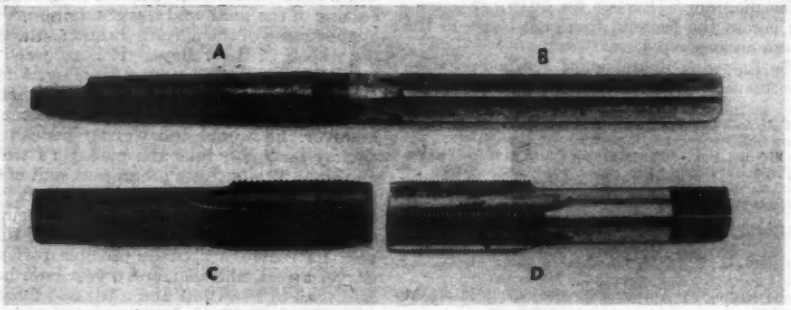
The centenary book records, as we have endeavoured to show, an interesting account of the early days and struggles of an undertaking which through the years has achieved and maintained an honoured place in this country's steel and allied industries. It also records the services which that undertaking rendered to the nation during two world wars. In 1945, Mr. S. Eric Osborn was elected Master Cutler and was thus the third Osborn to occupy that high office. During 1947 and 1948, a scheme of reorganisation was carried out, which resulted in the creation of subsidiary companies concerned with the manufacture of the various Osborn products. The parent company, Samuel Osborn and Co., Ltd., continued, and the number of people employed has been quoted as 2500. Mr. S. Eric Osborn became chairman in 1950, but his period in that office was regrettably short, his death occurring suddenly in July, 1951. The present chairman is Mr. F. A. Hurst, who has been in the company's service for practically the whole of his working life. Members of the fourth generation of the Osborn family now have a place in the business, which has reached its centenary. The book, which has been published in honour of the event, deals with the many changes which the years have brought. But there can be no doubt, as the author says, that "the company faces the coming century with the same courage and spirit of endeavour as did the founder a hundred years ago."

Sorting Tungsten Steel in Scrap Cutting Tools

THE present shortage of tungsten in this country makes its reclamation from worn and broken high-speed steel tools a matter of some importance. As is well known, the construction of such tools varies; some are made entirely of tungsten steels, some have carbon steel shanks with tungsten cutting portions, and others are made wholly of carbon steel. For this reason it is a matter of some difficulty to sort quickly and economically the tools containing tungsten which are the most valuable. Sorting methods which have been developed up till recently are relatively costly, and it is therefore of particular interest to note that a simple and effective system has been proposed by Mr. A. M. Armour, of the Metropolitan-Vickers Electrical Company, Ltd. This method, which is used in conjunction with grinding spark tests, has now been adopted by the company for sorting high-speed steel from carbon steel. The firm has sent us the following notes on the new sorting method.

It is well known that high-chromium bearing steels are very resistant to rusting, but it is not generally realised, however, that the 10–30 per cent tungsten steel alloys also are to a large extent resistant to rusting. The fact that this resistance is markedly superior to that of carbon steel can be made to furnish a very easily recognisable distinction between these two latter alloys.

The illustration shows a carbon steel taper shank *A* welded to a tungsten steel reamer *B* and a carbon steel tap *C* at the side of a high-speed steel tap *D*. These tools had been lying about in a workshop for several weeks, during which time they had been acted on by the normal atmosphere. It is obvious that the parts *A* and *C* have suffered much more rusting than parts *B* and *D*, and this fact, once pointed out, can be appreciated without any aptitude beyond normal perception.



TUNGSTEN STEEL AND CARBON STEEL IN SCRAP TOOLS

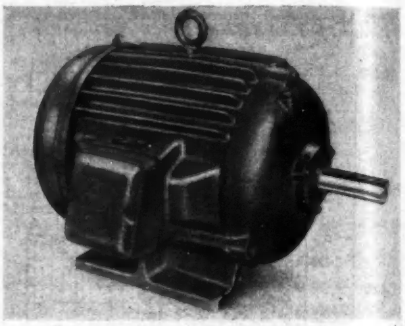
Such a process of rusting is lengthy, but it can be markedly accelerated by cleaning a small part of the surface with emery wheel or cloth, then wetting this with a strong solution of ammonium chloride (sal-ammoniac) in water, and leaving it in the air while still wet. In about fifteen minutes the carbon steel turns golden brown with rust, whilst the high-speed steel remains more or less free from rust, depending on the alloy. In the photograph the line of material change at the weld on the parallel portion of the reamer can be seen by the change in the rusting properties overnight after this treatment. With practice in the use of the method the degree of discrimination amongst alloys improves.

Standard Electric Motors

OUR illustration shows one of a range of standard electric motors introduced by the English Electric Company, Ltd., Queens House, Kingsway, London, W.C.2, to comply with the Draft British Standard CN(ELE) 6814, which gives dimensional standards and preferred outputs and speeds for a range of totally-enclosed fan-cooled squirrel-cage induction motors from 1 h.p. to 20 h.p. at four-pole speeds.

The dimensions specified in this draft specification are similar, except for the 1 h.p., 4-pole motor, to those laid down in the American NEMA Standard MG1—1949 but, for a given frame size, the horsepower outputs have been increased to accord more with the generally accepted practice in this country; the shaft dimensions have been adjusted correspondingly.

Before referring to the new range of motors, we may recall briefly the history of the draft specification on which the range is based. One of the important antecedents of the specification was the comprehensive report contributed by a technical committee of the Machine Tool Trades Association in July, 1949. After investigation in America, this committee recommended that a British Standard should be formed, based on the American NEMA frame sizes, but with modified outputs.



FAN-COOLED SQUIRREL-CAGE MOTOR 7½ H.P., 1450 R.P.M.

In September, 1949, the report of the committee for Standardisation of Engineering Products, the "Lemon Committee," was published. As a result of this report the British Standards Institution formed a committee from members of the British Electrical and Allied Manufacturers Association, users and Government departments, whose object was to prepare a draft specification to establish standard dimensions necessary to ensure that motors of different makes, complying with the specification, would be mechanically interchangeable for all normal applications to the driven machine. Relevant specifications from all over the world were carefully studied in order that the new standard should be universal. Finally, it was decided to adopt the dimensions laid down in the American NEMA Standard MG1—1949, but to increase the horsepower output per frame size in accordance with British practice. This decision resulted in the Draft British Standard Specification CN (ELE) 6814, which gives preferred outputs, speeds and dimensions for totally-enclosed, fan-cooled, squirrel-cage motors suitable for operation on three-phase, 50 c/s supplies at voltages up to and including 650V, and complying with the relevant requirement B.S. 168. It should be borne in mind, of course, that the document CN (ELE) 6814 is a draft, which was circulated to the industry for comment. It is still under consideration by the relevant committee of the British Standards Institution, and is subject to any alterations that may be decided upon as a result of the committee's deliberations.

Hitherto, although all electric motor manufacturers have had their own dimensional standards, these individual standards have not been interchangeable. Now, the prospect of standard outputs, speeds and dimensions offers benefits to both users and manufacturers

in the shape of improved and cheaper production and quicker deliveries.

Details of frame sizes, outputs and speeds of the English Electric "LY" range of motors which comply wholly with table 4 of the draft specification are tabulated herewith.

Motors in the English Electric "LY" range are robustly built, the stators being of one-piece cast iron construction, with integral feet and terminal box base. All working surfaces are accurately machined to ensure correct alignment of fitted parts. The stator cores, built up of high-grade alloy stampings welded together and machined to fine limits on both external and internal diameters, are wound with synthetic resin covered copper wire. Heavy pressboard with mica and/or black varnished cambric backing is used for the slot insulation. The wound assembly is impregnated in an automatic continuous oven to form a tropically-insulated unit, which is then pressed and keyed into the stator frame.

Particulars of "LY" Range of Motors

Frame size	2-Pole		4-Pole		6-Pole		8-Pole	
	H.P.	Speed	H.P.	Speed	H.P.	Speed	H.P.	Speed
B.183	1½	2860	1	1425	¾	930	—	—
B.203	2	2845	1½	1415	1	945	½	715
B.204	3	2870	2	1430	1½	945	¾	715
B.204	5	2870	3	1430	2	950	1	715
B.225	7½	2885	5	1445	3	960	2	720
B.254	10	2885	7½	1450	5	960	3	720
B.284	15	2900	10	1455	7½	965	5	720
B.324	20	2910	15	1465	10	975	7½	730
B.326	25	2920	20	1470	15	975	10	730

Pressure die cast construction is used for the rotor to form a practically indestructible unit. The rotor core is built up of the same alloy stampings as the stator core and has aluminium alloy bars and end-rings with integrally-cast fan blades.

The end shields are cast iron, well proportioned and accurately machined to give protection to the working parts and maintain correct alignment under the heaviest loads.

A 0·4 per cent carbon steel, having an ultimate tensile strength of 38/42 tons per square inch is employed for the shaft, which is fitted with metric bearings as recommended in B.S.S. 292—1939. The diagonally-split terminal box gives easy access to the terminals. Stock motors are despatched with the box on the right-hand side of the motor when looking at the non-driving end, with the cable entry pointing vertically downwards. The terminal box can be turned to give three further positions for the cable entry, each spaced 90 deg. apart. The stator can be reversed when the terminal box is required on the left-hand side of the machine.

The British Iron and Steel Federation's Annual Report

THE annual report of the British Iron and Steel Federation, dealing with the year 1951, has been issued this week. It opens with the comment that "the year 1951 will long be remembered for the many serious difficulties which have confronted the iron and steel industry." The ownership of eighty or so of the largest iron and steel producing companies, together with their subsidiaries, was transferred to the Iron and Steel Corporation of Great Britain on February 15th, and was a matter which brought organisational problems not only for the Federation but also for the individual companies. The relationship between the Iron and Steel Corporation and the Federation is dealt with in the report, particular reference being made to the "interim" understanding of the respective responsibilities which was reached last July.

The report also mentions, of course, the present Government's decision to introduce a Bill to annul the existing Iron and Steel Act. The Federation was duly consulted, and a special committee was appointed to consider any questions of policy which might arise and, if necessary, to engage in joint discussions on behalf of the industry. Although at the end of the year the precise form of public supervision proposed by the Government had not been announced, it is expected, according to the report, that an Iron and Steel Board, possibly with extended powers, will be re-established over the whole industry. The Federation has always felt, first, that impartial supervision on barod matters of policy can better be exercised by a body which itself has no ownership interest and is therefore free to take the widest view of national requirements without becoming involved in detailed financial questions; and, secondly, that control by a board with broad responsibility over the whole industry is preferable to the kind of control created by the present Iron and Steel Act, under which the Iron and Steel Corporation is responsible for part of the output of the iron and steel industry and part of the output of other industries.

In a reference to last year's steel production of 15,638,000 tons, the report observes that for the first time since 1945 steel output was less than that of the preceding year. But, it is added, last year's production was the second highest ever achieved in a single year. The difficulties experienced in connection with raw material supplies are dealt with at some length in the report, and the results of last year's steel scrap drive—outside the industry itself—are described as somewhat disappointing. The report acknowledges that "the raw materials outlook for the immediate future remains precarious." Pig iron production in 1951, amounting to 9,669,000 tons, was slightly below the estimate for the year, owing mainly to difficulties in the shipping of ore in the early months, and later to a coke shortage. Output has recently been running, however, at an annual rate of 10,280,000 tons.

A specially interesting section of the report is that which surveys the progress of the industry's development plan. More than 75 per cent of the work involved in the first development plan of 1945 is now either completed or under construction. The revision of the plan in 1948 envisaged a steel production capacity of 18,000,000 tons, which it is hoped will be reached by 1954. The Federation's advisory committee on development which was set up to report on the stage reached with the present plan and to formulate a second development plan has made considerable progress. In a number of cases, the report states, members of the committee, with the Federation's technical advisers, have examined proposals on the spot. The demand forecast for particular products has been compared with the supply expected in the light of the companies' proposals, and the raw material requirements of each district and of the country as a whole have been compared with the supplies likely to be available.

The report explains that, under the development plan, it was always envisaged that as new capacity came into operation there would need to be a substantial contraction in steel-making capacity at certain works which were no longer economic. A special committee was appointed in March last year to examine the effect of closing certain less economic plants, with a view to the most efficient use of the available raw materials in the production of about 16,000,000 tons of steel. In May last, the committee recommended that arrangements should be made for the early closing down of relatively high-cost steel-melting plants, with a total ingot capacity of about 750,000 tons a year. In September last, the Federation's executive formally appointed a steel capacity adjustment committee, under the chairmanship of Mr. E. H. Lever, to consider the problems arising out of the coming into operation of further new plant and to make recommendations for the closing of less economic plants.

The Kingsway Subway

THE seventh stage of the scheme for converting South London's tram routes to operation by buses will come into effect on the night of April 5th/6th. The last of the trams in North London will then be withdrawn, including the routes passing through Kingsway subway, as well as the trams serving Brixton, Brockley, Forest Hill and Norwood. It may be of interest to recall that the Kingsway subway was built at the same time as the Kingsway thoroughfare, and the tramway as far south as Aldwych was opened for traffic on February 24, 1906, with a station at the Aldwych end and an intermediate station at Holborn. In the same year, however, authority to continue the tramway southward was obtained and work on extending the subway was completed on April 10, 1908, thus effecting the physical link between the hitherto separate tramway systems of North and South London. The subway was only five-eighths of a mile long, but even in this short distance several forms of construction had to be adopted. At the northern end, access was gained by an open incline in the middle of the road (Southampton Row), which led to twin tunnels of cast iron, 14ft 5in in diameter, which carried the tracks under two pipe subways and a branch of the Fleet sewer beneath Holborn, rising up a 1 in 10 reverse gradient on the other side, into the Holborn station. From Holborn station to Aldwych station the tracks ran in a single 20ft wide tunnel, of rectangular section, with roof of steel troughing, just below the level of the street. The subway then turned westward and dipped to pass under the Strand; brickwork arches took the place of steel troughing on the section. Under the Strand itself, the single tunnel again gave place to twin cast iron tubes, which came to an end at the first of the brick piers of the viaduct leading to Waterloo Bridge. The final section of the work involved the underpinning of 360ft of this viaduct to permit openings to be made to accommodate a 20ft wide single tunnel. The operation was a delicate one as a failure in any of the piers would have resulted in the collapse of the whole street. Useful as was the new tram link, it was apparent from the start that it would have been of still greater use if double-deck cars could have been accommodated—an idea originally rejected because of the steep gradient necessary to enable a subway with sufficient headroom for double-deck cars to pass under the Fleet sewer. It was not for twenty-one years that the work of enlargement began, but it was then carried out with considerable speed and was completed in 1931; an account of it was given in our issue of January 30, 1931. The extra headroom was obtained by raising the roof of the tunnel for a short section at the northern end and lowering the rail level elsewhere. North of Holborn, the two cast iron tubes and brick arches were replaced by a new steel roof on steel stanchions built into concrete side walls, forming one wide tunnel just below street level; this work was made possible by diverting the Fleet sewer into the Kingsway sewer and supporting the two cross pipe subways on steelwork. Between Holborn and the Strand the side walls of the single tunnel were underpinned and the tracks lowered; under the Strand, where the tracks were again carried in twin tubes, the lower segments of these were removed in short lengths and new concrete walls built to carry the upper segments (in the meantime supported on timber)—an intricate operation in view of the heavy loads carried overhead. The stations at Holborn and Aldwych were completely modernised and considerably enlarged, great attention being paid to the lighting. Double-deck tramcars were put into service through the enlarged subway, which reopened on January 15, 1931, with three services (in place of the former one), making some 5000 journeys a week.

THE ENGINEER

Vol. CXCIII APRIL 4, 1952 No. 5019

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CONSULTANTS AND PUBLICITY

FOR the design of great engineering schemes, such as irrigation projects, harbour works, bridges, dams, water supply works, and the like, those in positions of authority tend, very naturally, only to employ as consultants engineers who are known to them by reputation to have had experience of the design of works of similar magnitude and the supervision of their construction. In fact, to consulting engineers' appointments the old biblical saying applies: "Unto every one that hath shall be given, and he shall have abundance." But the reverse also applies. For should the engineers of any country, whether through their own failings or through an accident of fate, have been deprived, for a period, of the experience of carrying out works of large magnitude, or should it merely appear to those in authority, who may very well be laymen, uninstructed in the engineering sciences and arts, that they lack experience, then it may well be feared that "from him that hath not shall be taken away even that which he hath." The authorities will look elsewhere for advice.

In the nineteenth century a very large proportion of the greater civil engineering works in the world outside Europe were designed by and built under the supervision of British engineers. But in this century the competition to undertake such work has grown keener. In particular, across the Atlantic and working within their own land, American engineers have erected some of the greatest civil engineering structures the world has known. They are now seeking work elsewhere. Nor are they seeking it unsuccessfully. Recently, for instance, a formal agreement was concluded between the Governments of the United States and of India whereby the U.S. Bureau of Reclamation will give advice and scientific and technical engineering service to the Indian Government. It is true that the services will not include project construction, direct supervisory work on the preparation of detailed project construction, design or specification drawings. But when advice has come from America there must necessarily be an impulse to place such work with Americans. If, then, British consultants are to continue to be appointed to carry out works of the first magnitude elsewhere than in this country, it is desirable—indeed, it has become essential—that the world at large should be told not only about their remarkable achievements in the past, but what they are doing to-day. For once let the ability of British consultants to carry out works of the first magnitude be doubted and they would soon find that such world-wide reputation as they might then still retain would slip from them. In consulting work, as in other fields of endeavour, nothing succeeds like success. But just as in law justice must not only be done, but must also appear to be done, so in consultancy not only must there be success, but consultants must also be seen to be successful. That is a point that seems to us to have been better grasped by Americans than by their British counterparts. For, over the past very many years, more publicity has been given, particularly in the world's lay Press, to the works of American engineers than to those of British engineers. The cause is not merely to be traced to the recent construction in the United States of a large number of great engineering works. It is to be found also in an attitude of mind amongst American consultants and contractors which welcomes publicity, so that they are prepared at all times during the construction of works to make detailed information available and provide facilities for the taking of photographs, the making of films, and so forth. For they realise, more fully, we think, than do British consultants, that those who authorise the construction of works of large magnitude are more likely to be laymen than engineers and are therefore more open to be impressed by published proof of what consultants have done than by their reputations within the profession itself, however high those reputations may be.

Since a time long before the war we have repeatedly stressed the need for consultants here to give more attention to publicity. We welcome, therefore a notice that appears in the March issue of the *Chartered Civil Engineer*, the bulletin of the Institution of Civil Engineers. It opens with the forthright remark that "the Council of the Institution is of the opinion that the public should be made better acquainted with the work done by the engineer and feels that much can be done by engineers themselves to bring this about," and it goes on to say that "engineers responsible could take steps to ensure that due recognition is given to the part played by the engineer when reports are being prepared for the Press," and that action of this character is not contrary to the ethics of the profession when it is "directed to providing the public with proper information on which to form an opinion as to the value of the work of the engineering profession." Machinery is suggested whereby prior notice could be given to the B.B.C. about work being carried out so that it could be filmed or recorded for broadcasting or televising, and it is suggested that engineers could take steps "to influence the making of films of works for which they are responsible." How very much we approve! For natural modesty and an understandable desire not to be bothered by non-technical reporters eager to find a good "story," rather than to write a factual account of what they see or hear, have, to date, been supported by doubts about the ethics of welcoming lay publicity. The major civil engineering institution has now publicly recognised the importance to civil engineering consultants (and, incidentally, to contractors, too!) of securing adequate publicity for the works, beneficent to the whole community, that engineers carry out. For our part, we believe that, in the world as it is constituted to-day, civil engineering consultants cannot expect to prosper unless their work is adequately publicised. We hope, therefore, that in the future British consultants will co-operate more readily than in the past with the lay, as well as the technical Press, with the B.B.C. and with film-making concerns. They will have only themselves to blame if publicity in the future about the works for which they have been responsible is inadequate to support the world-wide reputation for ability to carry out engineering works of the first magnitude which they would like to maintain and which it is to be devoutly hoped they will retain.

THE "BRITANNIA" LOCOMOTIVES

FEW locomotives in recent years have taken the road in a greater blaze of publicity than the first British standard "Pacifics" of the "Britannia" class. In October, 1950, Mr. Riddles, in his presidential address to the Institution of Locomotive Engineers, outlined the principles of design he had laid down. Early in 1951, Mr. E. S. Cox, in a further paper, described the design in detail and showed how the new standards were being evolved from a mass of design and performance data greater by far than anything available to any one of the chief mechanical engineers of the former com-

panies. In May of last year, the technical Press was invited to a demonstration of "Britannia" performances, by one engine on the stationary testing plant at Rugby, and by a second on the journey to and from Rugby, during which we had the opportunity of riding in the dynamometer car. We learned then of the full thermodynamic trials in progress, and from graphs which we were able to examine even at that early stage it seemed clear that the new design was already on its way to becoming established as a great success. During the summer "Britannia" class engines went into regular service on several important routes, and the general results, as indicated in reports reaching us from many sources, were so promising that we were moved to publish a leading article in our issue of October 12, 1951, under the title of "'Britannia' Locomotive Prowess." Some of those early results are contained in an article printed elsewhere in this issue. The runs set out there are not tests of maximum power output, nor of maximum steaming; they are no more than factual records of running in ordinary express passenger service. They will be found to contain many cases of light loading, and some with easy schedules. At the same time, however, there is included so severe a task as the working of the up "Cornish Riviera Express" from Penzance to Plymouth with a train load of 420 tons, so that the article as a whole does cover a fair cross section of day-to-day passenger service.

Our leading article had scarcely appeared, however, before news came of the mishap to engine No. 70,004, "William Shakespeare," on the "Golden Arrow." That this failure was a serious one seemed evident when shortly afterwards all engines of the "Britannia" class were temporarily withdrawn from service. With locomotives that had been so widely publicised it was only natural that extreme curiosity should have been felt as to the nature of the trouble. Rumours circulated orally, but the technical press maintained almost complete silence—a silence of understanding and sympathy in face of an unexpected source of weakness. Withdrawal was the only prudent course that Mr. Riddles could have adopted, until the cause of the trouble had been fully ascertained. Drastic though that course was, it is, however, by no means unique in British locomotive history. It is, for example, not generally known that at one stage a famous C.M.E. of the 1900–1914 period ordered the withdrawal of all engines of a celebrated class of four-cylinder 4–6–0s until a defect had been put right. But the glare of publicity did not shine upon him as it does upon the Railway Executive, and very few people outside that C.M.E.'s immediate *entourage* ever heard about it. It is true that the trouble was a simple one compared with that confronting the Railway Executive, and it was speedily corrected; but that does not alter the fact that the engines *were* withdrawn.

With the "Britannias," slipping at high speed seems to have been the major cause of the trouble. We understand that similar difficulties have been experienced with some large overseas engines having roller bearings on the coupled-wheel axles, and the Interchange Trials of 1948 showed that some British "Pacifics" that have plain bearings are prone to considerable slipping, yet of so imperceptible a kind that the drivers can be unaware of it. With the "Britannias" the stresses set up by this slipping led to the movement of wheels on the axles, and in the case of "William Shakespeare" to the fracture of a coupling-rod. In consequence, the design has since been modified in two respects by plugging the hollow axles at each end for the length of the wheel fib, and by use of coupling-reds of plain rectangular section instead of fluted ones. These changes have been carried out, and for some months now the locomotives have been back in traffic, still, however, under close observation. In the meantime, the full thermodynamic trials at Rugby Testing Station have been supplemented by some remarkable road tests between Leeds and Carlisle. At the time of our visit to Rugby in May last, one of these engines had successfully maintained a steaming rate of some 33,000 lb of steam per hour, and we understand that even this figure has now been exceeded. The official report on these trials is now available, and we are sure it will prove a document of absorbing interest. But as the article published elsewhere in this issue indicates, heavy load trains do not represent all the duties to be undertaken by mixed traffic engines of this power classification, and it will be very interesting to learn, in due course, how the economy of the "Britannias" is maintained when running at considerably below optimum capacity.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

TREVITHICK'S FIRST RAILWAY LOCOMOTIVE

SIR,—I am obliged to Mr. Forward for his reply to my letter printed in your issue of March 7th.

Mr. Forward may have been "put on to a good thing" by John Randall's "History of Madeley," but I submit that the Reynolds' evidence itself is very questionable. Mr. Forward estimates that Mr. W. A. Reynolds' reminiscences were recorded between 1872 and 1880, the date of publication of the "History." It is clear, then, that Mr. Reynolds was not recording a fact within his own knowledge, but something he had heard from his uncle. He, himself, was probably an old man at the time and not only are the reminiscences of old men unreliable, but in this case Mr. Reynolds' "memory" seems to have been prompted by a sight of Trevithick's letter of 1802. His comparison of Trevithick's locomotives with locomotives of the 'seventies, which Mr. Forward endeavours to excuse, ought to put us on our guard.

The little arithmetical difficulty to which Mr. Forward refers is readily cleared up. He based his calculation on the Penydarran engine and I on the Coalbrookdale engine. The double stroke of the latter is 6ft, the circumference of the driving wheels is 9ft, hence if the rule piston speed=road speed was to be observed, a gear ratio of 2 : 3 should have been used. That it was not was, as I said in my letter, a point in support of Mr. Forward's contention that the drawing does not show the Penydarran engine.

I think Mr. Forward is also referring to the Penydarran engine when he gives 1¼in as the width of the wheels. Those of the Coalbrookdale engine are given as 1in. It is difficult to believe that C.I. wheels 3ft in diameter with rims of about 1 square inch cross-section could have endured the slings and arrows of an outrageous plateway for long, especially with a lop-sided drive that must have caused many knocks and bangs. In spite of Mr. Forward's evidence, I must admit to still feeling uneasy about that drive—it is such very bad engineering.

Now about the relics of the engine. Mr. Llewellyn said in Randall's "History"—see THE ENGINEER, page 266, February 22nd—that the boiler was then—*circa* 1870—in use as a water tank at Lloyd's Cranston Pit, and the fire-tubes and a few other parts at Madeley Wood. To convert the boiler into a tank, it would have been necessary to dismantle it completely, and to put a new blank on one end. Was it worth it? The fire-tubes were, no doubt, of wrought iron. If they had been lying out in the yard at Madeley Wood for a substantial part of the period between 1803 and 1875, not much of them would have remained at the date of Mr. Reynolds' reminiscences. Here, again, I would not place much trust in an old man's evidence. One knows very well how traditions tend to gather round objects.

By the way. I can see no indication of draught gear in the 1803 drawing. Can Mr. Forward tell us how these early engines were coupled to their trains?

LOUGH. PENDRED

Twickenham, March 31st.

ASSESSMENT OF LOCOMOTIVE PERFORMANCE

SIR,—I was interested to read the letter, on "Assessment of Locomotive Performance," by Mr. Munnion in your issue of THE ENGINEER, March 21st.

Mr. Munnion remarks that the steam chest pressure of an "A-3"-class locomotive seldom rises above 205 lb per square inch.

I wonder if he is correctly informed? The boiler pressure is 220 lb per square inch.

F. L. E. BEEDHAM

South Woodford, March 26th.

The Electrical Engineers' Exhibition

THE first Electrical Engineers' Exhibition, organised by the Central Regional Council of the Association of Supervising Electrical Engineers, was held in the Royal Horticultural Society's New Hall, Westminster, S.W.1, on Friday and Saturday, March 28th and 29th. Among the exhibitors were the British Electricity Authority, the Electrical Research Association, the Electrical Development Association and the Association of Supervising Electrical Engineers, emphasising the part played by co-operative effort in the production and application of electricity. More than seventy individual firms showed examples of their products, which included high and low voltage cables and accessories, electrical distribution systems, relays, switchgear, lighting and heating equipment, motors, instruments, welding plant, electronic equipment and a variety of domestic electrical apparatus.

NICKEL ORE PIPE-LINE.—The International Nickel Company of Canada, Ltd., has completed a pipe-line, 7½ miles long, through which nickel ore bulk concentrate is pumped from the concentrator at Creighton to the reduction plants at Copper Cliff. Economies effected by the pipe-line transport allow lower grade ore to be worked and the line has been integrated into a system which also carries tailing to a disposal area. The system is carried on trestles high enough to ensure that the concentrate lines between relay pumping stations will be self-draining. At Creighton, 1800 tons of concentrate and 8200 tons of tailing are produced per day and water added to the concentrate makes a pulp which flows at 800 gallons per minute, while the tailing pulp flows at 2500 gallons per minute.

Obituary

SIR ANDREW DUNCAN, G.B.E.

For many years, Sir Andrew Duncan took a prominent part in the industrial affairs of this country. His death, which occurred in London, on Sunday last, March 30th, following several weeks of illness, is deeply regretted. Sir Andrew, who was sixty-seven, had been chairman of the executive committee of the British Iron and Steel Federation since 1935, except for the period 1940–45, when he served in the wartime Government as President of the Board of Trade and Minister of Supply.

Andrew Rae Duncan was born at Irvine, Scotland, in 1884. He was educated at Irvine Academy and at Glasgow University, where he graduated both in arts and law, and subsequently became a partner in a firm of solicitors in Glasgow. In that profession, Andrew Duncan began to specialise in industrial affairs, which brought him into contact with a number of shipbuilding and engineering firms. During the first world war Sir Andrew was appointed secretary to the Shipbuilding Employers' Federation, later on becoming secretary to the Shipping Controller's merchant shipbuilding advisory committee, and—when Sir Eric Geddes was First Lord of the Admiralty—joint secretary to the Admiralty Shipbuilding Council. Thus, as a young man, Sir Andrew acquired extensive experience as an industrial conciliator, experience which proved to be of great service in the many other important offices he held in the succeeding years of his career. At the end of the first world war Sir Andrew was appointed coal controller in succession to Sir Evan Jones. It was a particularly difficult period in the history of the coal mining industry, as the change-over of the mines from wartime public control to private ownership was taking place. That task was successfully accomplished, under Sir Andrew's guidance, in 1921, the year in which he received his Knighthood. A year earlier he had been called to the Bar and was elected a Bencher of Gray's Inn; he also, about the same time, became chairman of the newly-formed advisory committee of the Coal Mines Department, and permanent vice-president of the Shipbuilding Employers' Federation. In the years following the first world war Sir Andrew was called upon to serve on several commissions and inquiries. They included the dock strike inquiry early in 1924; the Royal Commission on National Health Insurance, which began its work in July of the same year; and the Royal Commission which investigated the coal industry of Nova Scotia in 1925. Sir Andrew was chairman of this last-named Commission and, whilst in Nova Scotia, received the honorary degree of LL.D. from Dalhousie University, Halifax. Concurrently with the investigation of the coal industry in Nova Scotia, Sir Andrew presided over another Royal Commission which was set up to inquire into certain grievances of the Eastern Provinces of Canada.

The next important office which Sir Andrew was invited to take was the chairmanship of the Central Electricity Board, which was set up as a result of the Electricity (Supply) Act, 1926. The function of the Board, it will be recalled, was to co-ordinate the generation and main transmission of electricity in this country. The rapid progress made with the establishment of the grid system was in a large measure due to Sir Andrew's administrative ability and energy while chairman of the Board. He relinquished the chairmanship of the Central Electricity Board in 1934 to take up another responsible position, which was that of independent chairman of the executive committee of the British Iron and Steel Federation. The Federation was charged by the Government of the time with the task of reorganising the steel industry. Under Sir Andrew's direction, which—apart from the war years—has been continuous since the beginning of 1935, the Federation has indeed become a national organisation in the full sense of the term. When war came in 1939, the iron and steel industry found itself fully equipped to meet the heavy demands placed upon it.

SIR ANDREW DUNCAN, G.B.E.

At the beginning of the war Sir Andrew was appointed Controller of Iron and Steel under the Ministry of Supply. After a few months in that office he was invited by the then Prime Minister, Mr. Neville Chamberlain, to become President of the Board of Trade, and throughout the whole of the war his services were retained in the Government. When Mr. Churchill became Prime Minister, Sir Andrew was appointed Minister of Supply, returning in July, 1941, to the Board of Trade as President. He again became Minister of Supply in February, 1942, in which office he remained until 1945. From 1940 onwards Sir Andrew sat in Parliament as member for the City of London. He did not, however, seek re-election in 1950.

When the war ended, Sir Andrew resumed his duties with the British Iron and Steel Federation, which was then engaged upon the post-war plan for the reconstruction and modernisation of the steel industry. Again, his quick grasp of technical and financial details and his vast industrial experience were manifested, and the reconstruction programme, involving an estimated expenditure of £250,000,000, was accepted by the industry and the Government less than a year after the conclusion of hostilities. Despite the uncertainty about its future, there was no delay on the part of the steel industry in making a start on its reconstruction programme. The Labour Government was intent upon the nationalisation of the iron and steel industry, and when the Bill for that purpose was introduced, Sir Andrew was the leading opposition speaker, a task for which he was well equipped. In putting forward the case against nationalisation, he was able to speak from an intimate knowledge of the organisation and operation of the industry. In the five years in which he continued in Parliament after the war, Sir Andrew's principal speeches were concerned with the steel industry. That which he delivered, on November 17, 1948, during the debate on the second reading of the Iron and Steel Bill was indeed a masterly exposition of the case against nationalisation. In that speech, Sir Andrew claimed that there were no pressing difficulties known to the industry or raised by the Government which justified the adoption of a completely new organisation without regard to its possible damage. "If there were any need to discuss further development of public policy," he said, "there existed all the machinery with which to do it, for the steel industry was thoroughly organised to discuss and implement public policy." Sir Andrew concluded his contribution to the debate by urging that the technique of running great State organisations was a subject to which the Government must apply more research and gain more experience. There could be no justification, he asserted, "for venturing with confidence into a great new range of complex and complicated industrial activity."

Sir Andrew's participation in the activities of the British Iron and Steel Federation continued until the end of his life. Latterly, he had taken an energetic share of the work involved in furthering the industry's scrap campaign, which was initiated early last year. At the same time, there were many other concerns which benefited from his wise counsel and industrial experience. He was a director of Imperial Chemical Industries,

Ltd., the Royal Exchange Assurance Company, Ltd., the North British Locomotive Company, Ltd., and the Dunlop Rubber Company, Ltd. From 1929 to 1940 he served as a director of the Bank of England. Sir Andrew was one of H.M. Lieutenants for the City of London, and from 1939 to 1940 was High Sheriff of the County of London. He was created G.B.E. in 1938.

SIR JAMES CALLANDER

As briefly announced in our last issue, the death of Sir James Callander occurred at his home at Newby Bridge, Lancashire, on March 23rd. Sir James, who was in his seventy-fifth year, was born in April, 1877, in Newton Stewart, Wigtownshire, and was educated at the Ewart High School. Following a year's study at the Glasgow and West of Scotland Technical College, James Callander became a premium pupil with the engineering firm of Fawcett Preston and Co., Ltd., of Liverpool, and continued his technical education at the Liverpool School of Science Technology. Upon the completion of his training in 1898, he spent a short time as assistant mechanical superintendent of the Mersey Docks and Harbour Board before joining Vickers, Ltd., at Barrow-in-Furness. In 1903 he was appointed assistant chief draughtsman, which post he held until 1911, when he became works manager and as such he was responsible for the machinery installed in the battle cruisers "Lion" and "Princess Royal." In course of time Sir James gradually assumed more and more responsibility and eventually rose to the position of general manager of the shipbuilding and engineering departments at Barrow and of the Naval Yard at Newcastle upon Tyne. He was appointed a director in 1936 and four years later became acting deputy chairman. His services to shipbuilding were recognised by his creation as a Knight Batchelor in 1941. Sir James continued to be a member of the board of Vickers-Armstrongs, Ltd., until 1945, when he retired, but he remained a director of Vickers, Ltd., for a further two years. He was a member of the Institution of Mechanical Engineers and of the Institution of Naval Architects, of which body he served as a Member of Council for fifteen years until 1950. He was also, for a period, a member of the technical committee of Lloyd's Register of Shipping.

Literature

Structural Theory and Design, Vol. II, by J. McHARDY YOUNG. London: Crosby Lockwood and Son, Ltd. 39, Thurloe Street, S.W.7. Price 25s.

THE first volume of this book appeared in 1950 and dealt with the main structural materials and the elementary parts of the theory and design of structural members and simple statically determinate frameworks. This part is now joined by the second volume, which covers the more advanced aspects of structural theory and design; it is therefore of particular interest to the student specialising in structures and to the practising structural engineer.

The book begins with a treatment of redundant frameworks on the basis of the principle of work or strain energy, the distribution method and various approximate methods of solution. This rather short section is followed by lucid chapters on hinged and fixed arches of various shapes. Circular and parabolic arches are analysed in detail and most solutions are presented in the form of influence values for ready application in practice. The author's well-illustrated treatment of portals and rigid single and multi-storey frames is particularly instructive, because he deals with all the principal methods of analysis, namely, direct comparison of deflections, slope deflection method, minimum strain energy analysis, arch theory, moment distribution method, column analogy and experimental methods. Many of the fully-worked examples are solved by several of these methods for comparison, and to aid the reader in deciding which is the best approach in any particular case.

After this clear presentation of frequently difficult structural problems, the subsequent chapters on earth pressure, earth retaining structures and foundations leave a good deal to be desired. The admittedly difficult task is attempted of presenting both the classical theories and modern principles of soil mechanics. As a result, the reader, particularly when specialising in structures, is likely to be somewhat confused and burdened with sections, such as that dealing with the stability of slopes, which are of little interest to him. Probably, much would be gained if the assumptions on which the various methods are based were clearly stated, and the consequent limitations of the theories were pointed out. Thus, in estimating the passive earth pressure on rough walls, the use of Coulomb's wedge theory leads to appreciable errors on the unsafe side, while the various bearing capacity theories mentioned by the author for shallow foundations on sands and in some cases also for clays are known to be very conservative and have for some time beeen superseded by more rational methods. Similarly, in the treatment of piled foundations, little is gained by presenting numerous different pile driving formulæ, which are known to be unreliable, particularly for clays, in view of the assumptions on which they are based.

The last chapters of the book revert to miscellaneous structural problems, such as cables, long-span and movable bridges, and plates, all of which are necessarily dealt with only briefly, with many references to more extensive accounts. The volume concludes with the problem of the design of structural connections, a matter which had received little attention in many textbooks. Steelwork connections by bolts, rivets and welding, and timber connections by various methods, including split ring and other shear connectors, are well illustrated by examples. The practical value of the latter section is enhanced by the appendices, which contain, among other information, many useful tables of the mechanical properties of home-grown and empire timbers.

This up-to-date book, which combines theoretical and practical knowledge to a marked degree, should be of service to students and practising engineers alike.

An Introduction to the Theory of Control in Mechanical Engineering. By R. H. MACMILLAN. London: Cambridge University Press, Bentley House, 200, Euston Road, N.W.1. Price 30s.

THERE is an extensive literature on servo-mechanisms and process controls, but up to date there has been a lack of a fundamental textbook dealing with the common basic principles of control theory. The present book sets out to remedy the omission, primarily mathematically, with a minimum of reference to constructional detail, and without the usual amount of argument by analogous electrical circuits, which is particularly refreshing to those who have to do with mechanical controls. The reader who has understood and assimilated the contents of this work will have acquired a powerful tool of wide application which he should have little difficulty in applying to his particular problem; this is by no means always the case with books or papers written primarily around one field of control application.

The first part of the book consists principally of descriptions of control principles, elements, systems, and performance which are clearly handled, although the author is least successful in the description of the hydraulic system components which falls between an outline of principles and practical details of construction. The qualitative examination of control systems and performance leads to the idea of transfer functions and the characteristic and governing equations of systems. Non-linear and in particular, human element systems are briefly touched on in a short qualitative discussion only. The remainder of the book gives a full account of transient and harmonic response, both by analytical (Laplace transform) and graphical (Nyquist diagram) methods.

This is a good book; so good that a revised edition should be produced soon in which some of the more obscure arguments are clarified and the remaining misprints and errors corrected. A new edition would be improved by further worked examples; at present these are few and far between, although a fair number of problems are included with answers in most cases. The diagrams are stated in the preface to be illustrative only and unsuitable for computation; in the case of one of the few which it would be helpful to use in this way, Fig. 19.16, the diagram is actually in error and does not agree with the text.

SHORT NOTICES

Welding Practice: Volume I, Welding Methods and Tests. Edited by E. Fuchs, M.A., A.M.I.Mech.E., and H. Bradley, M.Met. London: Butterworths Scientific Publications, Ltd., Bell Yard, Temple Bar, W.C.2. Price 17s. 6d.—This is the first of three complementary volumes dealing with specific problems in the welding of ferrous and non-ferrous metals. It is based upon a series of separate booklets or sections by members of a panel drawn from various divisions of Imperial Chemical Industries, Ltd. The primary object of the work is to meet the needs of designers, draughtsmen, works and research engineers, inspectors and foremen in charge of welders, and it is not claimed to be a general or comprehensive treatise on the subject. The first of the five main sections deals with welding processes and their applications. In the second section on the metallurgy of welding the physical and mechanical properties of metals and alloys are first dealt with briefly, followed by notes on the structure of weld metal and its refinement, the hardening of steel welds by rapid cooling, and impurities. After then dealing with the methods used for the examination and testing of welds, a review is given of welding equipment and shop lay-out. Welfare and safety of operatives engaged in welding are of the utmost importance and the final chapter of the book is devoted to this subject. All the information given in the book is presented in concise, readily understood language, which should appeal to all its users, who, if they wish for further details on any particular subject, will find a useful selection of text books in a bibliography at the end of each chapter. We think that all engineers whose work calls for a general rather than a detailed knowledge of welding processes and equipment will find this a useful reference book to have in their libraries.

The Institute of Metals

No. I

THE annual general meeting of the Institute of Metals was held at the Park Lane Hotel, London, from March 25th to 27th.

On Tuesday, March 25th, Professor A. J. Murphy, the retiring President, took the chair. After he had welcomed visitors and members from overseas, the secretary announced that since the Autumn Meeting in Venice, in September of last year, 279 members had been elected, the present membership of the Institute being 3832. He also reminded members that the Autumn Meeting, 1952, would be held in Oxford from Monday, September 15th, to Friday, September 19th, inclusive.

The chairman then moved the adoption of the Report of Council for the year ended December 31, 1951, which had been printed in the February, 1952, issue of the *Journal of the Institute of Metals*.

Dr. Ivor Jenkins seconded the motion, which was carried.

The Hon. Treasurer presenting his Report, and moving the adoption of the Accounts for the financial year, ended June 30, 1951, said that during the year, there had been an increase in the difference between income and expenditure of £909, resulting in an increased deficit of £2406. It had been met by a transference to the General Fund of the remainder of the war-time emergency Fund, £1590, and by a transfer of £516 from the newly-created Industrial Donations Fund. The extinction of the War-time Emergency Fund was an opportune time to say once again how indebted the Institute was to the subscribers to that fund during the war years. The possession of such a fund had assisted very considerably in stabilising the finances and meeting the growing activities of the Institute during the post-war years. The main reason for the greater increase in expenditure than in income was to be found in the continuing rise in the costs of publication, which was the principal activity. It was now possible to obtain a more complete picture of the Industrial Donations Fund. In the financial year, 1950–51, the receipts, including income tax recovered, amounted to £9334. In the current year, to date, and on the same basis, the income was roughly £7400. That gave a total received up to last week of £16,700. It might be envisaged that in the seven years covered at present by the fund, covenants and subscriptions which might possibly be recurring, together with single donations, would mean that the total amount accruing over the seven years to the Institute would be of the order of £80,000, assuming that income tax remained at the present rate. What might happen in seven years' time, no-one could predict. It was certain that without some extra income equivalent to that now coming in, the Institute's activities would suffer.

Election of Officers for 1952–53

The secretary announced the names of members elected to fill vacancies on the Council for the year 1952–53, as follows:—

President: Dr. C. J. Smithells; Vice-Presidents: Mr. G. L. Bailey and Dr. S. F. Dorey; Honorary Treasurer: Mr. E. H. Jones; Ordinary Members of Council: Mr. Alfred Baer, Mr. N. I. Bond-Williams, Dr. N. P. Inglis, Dr. Ivor Jenkins, Dr. A. G. Ramsay, Dr. H. Sutton, Major P. Litherland Teed, and Mr. W. J. Thomas.

It was further announced that the Council had elected Professor F. C. Thompson to be Senior Vice-President for the year 1952–53, and that he would be the Council's next nominee for the Presidency of the Institute.

Awards of Medals

The secretary announced that the Council had made awards of Medals as follows:—

The Institute of Metals (Platinum) Medal for 1952 to Mr. William Sydney Robinson, until recently president of the Consolidated Zinc Corporation, Ltd., in recognition of his outstanding services to the non-ferrous metal industries in developing the Australian zinc-lead industry and the British zinc industry; the W. H. A. Robertson Medal for 1951 to Mr. C. E. Davies, for his paper on "The Cold-Rolling of Non-Ferrous Metals in Sheet and Strip Form," published in the *Journal of the Institute of Metals*, 1951, Vol. 78; and the Rosenhain Medal for 1952 to Professor André Guinier, Professor of Physics at the Sorbonne, in recognition of his outstanding contributions in the field of physical metallurgy, particularly in connection with precipitation phenomena.

A vote of thanks to retiring members of Council was then moved and carried with acclamation. Thereafter Professor Murphy introduced the new president, Dr. C. J. Smithells, and inducted him into the chair. In a short speech, Dr. Smithells expressed his appreciation of the honour done him. After a vote of thanks had been carried to the retiring president, Dr. Smithells presented his address.

We print below some extracts from the address.

Presidential Address

International Co-operation.—I need hardly stress the cosmopolitan character of the Institute; our membership is international. The value of the closest co-operation with metallurgists in other countries has been stressed by many presidents in the past. Many of our autumn meetings have been held in Europe at the invitation of other metallurgical societies. The Council has now decided that, in future, in every three autumn meetings, one shall be held outside the British Isles, one shall be held in the provinces, and one in London, when a foreign metallurgical society will be invited to hold its meeting side-by-side with that of the Institute. We hope that in this way we shall have an opportunity of returning some of the hospitality which we have received so often from kindred societies abroad. We have honorary corresponding members to the Council in twelve different countries, and very friendly ties with the leading metallurgical societies in Europe and America.

Research.—A matter in which the Institute has played its part is in the practical application of scientific knowledge to industrial processes. Sir George Goodwin, in 1920, commented that while he had read and heard a great deal about the advantages that must result from the application of science to industry, a large portion of it had remained for a long time, and still remained, in the abstract, and was not really applied. And Dr. Rosenhain, in 1928, said, "It is not a bad thing, even for the most scientific worker, to pause at times and consider the nature and possible practical utility of the work on which he is engaged." Sir Henry Fowler, in 1932, again laid great stress on this matter, and said that one of the great problems of the day was the "marrying-up" of research with the practical application of the results obtained. He felt, therefore, that one of the objects which should always be borne in mind was to get the improvements they thought they were able to make put to a practical test as early as possible.

It was not until about 1948, however, that someone in official circles invented the term "operational research" to cover this activity, which had been constantly in our minds and had long been one of the normal tasks of industrial research teams. The various symposia which we have held in recent years have been a very direct contribution in this field.

There is another metallurgical field, however, which the Institute has deliberately refrained from entering until very recently, and that is that of metal reserves and metal conservation. In 1924, Professor Turner expressed the opinion that the whole of the known base-metal supplies of the world would not last for many years at their current rate of consumption, and that a shortage of supply could be expected within the lifetime of persons then living. He added that it was clear that the supply of base metals in future was likely to be restricted to an extent which had not hitherto been contemplated. Of aluminium alone, he said, there appeared to be an unlimited supply. Dr. Desch returned to this subject in 1938, but added that: "To discuss these questions, tempting as they are, would be to travel far beyond the scope of this Institute."

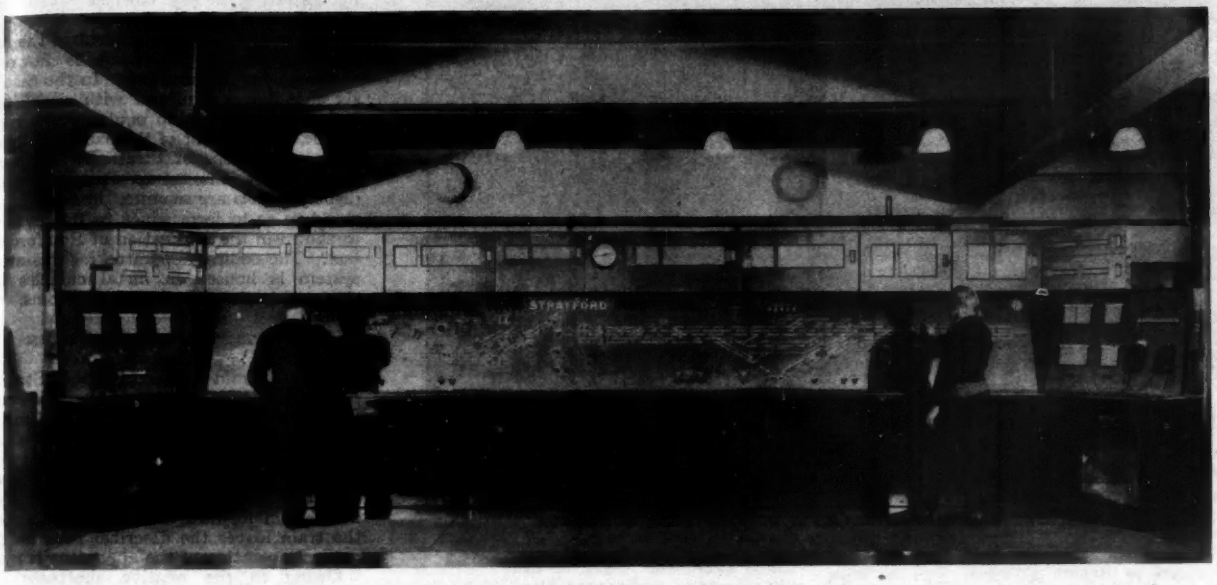
However, last year, Professor Murphy, realising the increasing importance of this subject, said that it appeared to him that there was a clear opportunity for the Institute to perform a public service by devoting some attention to those aspects of metallurgical science and industry concerned with the resources of metals on which the non-ferrous metallurgical industry is based, and with the most efficient utilisation of those resources. Following this suggestion, the Institute organised a general discussion on this subject in October last year, to which contributions were made not only by metallurgists, but also by leading geologists, economists, and representatives of Government Departments. While the world situation is creating a serious shortage at the present time, the pessimistic forecasts which have appeared at intervals for the last fifty years would hardly seem justified, at least while so much of the North American Continent remains unexplored.

Education.—I cannot omit some reference to another subject in which the Institute has had a continued interest, namely, metallurgical education. The importance of metallurgical training has been stressed on many occasions by our presidents, and eventually we had an opportunity to express our views in a most effective manner. Mr. H. S. Tasker, who devoted much time and thought to this subject on our behalf, dealt with this subject in his address in 1950.

In 1943 the Department of Scientific and Industrial Research appointed a committee to consider the steps necessary to secure an adequate supply of trained metallurgists in the post-war period. At the same time, the Board of Education, as it was then, approached the various institutions interested in metallurgy, pressing for the establishment of National Certificates in Metallurgy, and there was also among working metallurgists a demand that a qualifying organisation concerned specifically with the science and practice of metallurgy should come into being.

(To be continued)

TRAIN DESCRIBER SYSTEM ON LIVERPOOL STREET–SHENFIELD ELECTRIFICATION



DESCRIBER DISPLAY INSTRUMENTS IN STRATFORD SIGNALBOX

Liverpool Street—Shenfield Train Describer

The new train describer system associated with the resignalling scheme for the Liverpool Street–Shenfield electrification is now in service. It operates over a four-track, continuously track circuited section of line between Liverpool Street and Romford, with a four-track branch from Bethnal Green to Hackney Downs, a double track branch from Bow Junction to Gas Factory Junction and two additional tracks from Liverpool Street to Bethnal Green.

THE train describer system for the resignalling on the Liverpool Street–Shenfield electrification is the largest of its kind to be installed. It involves the main line signalboxes at Liverpool Street, Bethnal Green, Mile End, Bow Junction, Stratford, Forest Gate Junction, Ilford, Ilford Carriage Sidings, Goodmayes, Chadwell Heath and Romford. The system is fully automatic in that a description which is initiated at Liverpool Street or Romford is automatically transferred from signalbox to signalbox in step with the progress of the train.

Every signalbox is provided with a transmitter and a "Last Sent" indicator for each track leading away from the box and with a receiver indicator for each track approaching the box. The receivers consist, in general, of a number of indicating lamps (varying from eleven to twenty-nine) arranged in a horizontal row. These lamps are repeated in as many horizontal rows as may be necessary. The bottom row is labelled "Third in Section" and the rows above—in ascending order—"Second in Section," "First in Section," "At Signal *X*," "At Signal *Y*," "At Signal *Z*," and "Last Sent." It will thus be seen that each vertical row of lamps represents a train which appears as 3rd, 2nd or 1st in section (depending on how many trains are between the signalbox in question and the box in rear), and then appears successively as being at each of the various signals controlled by the signalman until it finally reaches the position of "Last Sent," which indicates that it has passed into the section ahead.

As shown in one of the illustrations on the next page, the vertical rows of lamps are divided into two groups, the left-hand group consisting of seven vertical columns headed "S.E.P.G.C.L. and M." Illumination of one, two or three of these lamps indicates the class of train and the right-hand group of indications denote the destination of the train. Thus a full description of a train is given by the illumination of one or more of the various seven lamps, plus a destination lamp, for example, "SEPSO" indicates a special express passenger train for Southend. The illuminated description of the train moves upwards as the train passes from signal to signal.

The set-up units consist of panels equipped with push-keys for setting up the required train description and destination. Twelve description keys are fitted in each signalbox, but the number of keys for destination varies according to the locations. "Interpose" and "Clear" keys are also provided for introducing or clearing descriptions at certain selected signals. Co-operative cancelling keys are fitted so that the last train transmitted to the box ahead can be cancelled.

In the event of failure of any part of the signalling equipment which may be used for controlling the working of the train describer, the signalman can operate an emergency switch (one per line) which cuts off the controlling functions of the system and, in effect, converts the apparatus to a manually operated system. When working under these conditions, train descriptions are transmitted from signalbox to signalbox by interposing directly into the "Last Sent" register which, after accepting the description, transmits it at once to the box ahead. The description in the "Last Sent" register flashes until a check has been

DISPLAY INSTRUMENTS AND SET-UP PANEL IN GOODMAYES SIGNALBOX

TRAIN DESCRIBER EQUIPMENT

PEDESTAL CABINET INSTRUMENTS IN STRATFORD SIGNALBOX

DESCRIBER APPARATUS IN HACKNEY WICK SIGNALBOX

SET-UP UNIT IN STRATFORD CONTROL DESK

received from the forward instrument to indicate that the description has been correctly received. When working under the emergency conditions described above, trains are cleared from the "In Section" part of the instrument by operating a key labelled "Clear 1st in Section."

Examples of the arrangement of the apparatus in some of the signalboxes is shown in the accompanying illustrations. In the case of the six signalboxes equipped with signalling control panels, the set-up equipment is mounted on the desk in front of the panel, as illustrated here in the case of Stratford. Where lever frames exist, the set-up equipment and the display panels are mounted in cabinets, which stand so as to form wings to the lever frame, as shown in the illustration of Romford signalbox. The coding apparatus for operating the system is housed in metal cubicles accommodated in the signalbox relay rooms.

OPERATION OF THE SYSTEM

When a train leaves Liverpool Street, Gas Factory Junction, Hackney Downs or Romford, to proceed into the area covered by the system, the signalman sets up the appropriate description and interposes it into the signal position next ahead of the train. Operation of the overlap track circuit of this signal passes the description forward and from that time until the train leaves the describer area no further manual operation of the apparatus is required.

Owing to the relative shortness of the sections on this line, it was considered that if transmissions of a description to the box ahead were delayed until the train had reached the overlap circuit of the last controlled signal, the signalman ahead might not have sufficient warning of the approach of the train. To meet this possibility an "early retransmission" facility has been introduced: it permits forward transmission of a description when the train is passing through the intermediate signal registers, provided that all signals ahead of the train are in the clear position. In extreme cases the description is retransmitted a few seconds after it has been received from the rear signalbox. When early retransmission has been effected an indicating light appears alongside the description on the display panel. This "transmitted" indication then steps forward with the description, being finally extinguished when the train passes the last controlled signal and the description is transferred to the "Last Sent" register.

In the case of up-line trains for Liverpool Street, the destination indication "LV" ceases at Bethnal Green and only the description of the train is automatically transmitted forward to Liverpool Street. When retransmission of this description begins a buzzer is sounded on the timekeeper's desk in Bethnal Green signalbox. This man's desk is provided with a special panel enabling him to set up the platform number at Liverpool Street, into which the train is to be directed by the Liverpool Street signalman. These platform numbers are manually transmitted by the Bethnal Green timekeeper and appear on the destination section of the Liverpool Street display panel alongside the already received description.

If the overlap track circuit of the last controlled signal becomes occupied when there is no description in the register relevant to this signal, an "ND" (not described) indication is exhibited on the display panel and an alarm bell sounds continuously. Both the bell and the "ND" lamps are restored to normal by operating the "Bell cut-off" key. The signalman must then transmit the description of the train by interposing it into the "Last Sent" register.

A simple form of train describer is provided for the two "Carriage Lines" between Bow Junction and Stratford. These lines are signalled for use in both directions and each is equipped with a transmitter and receiver at both terminal signalboxes. The train description and destination are combined in one indication and the apparatus is non-automatic in operation. Twelve line wires are used between Bow Junction and Stratford for the

four circuits, the codes being transmitted on the "pattern" system.

All uniselectors and relays are operated from a 50V d.c. source. Standard Post Office telephonic apparatus is used throughout, the uniselectors being of up-to-date single-coil design. An innovation is the use of a "both-way" uniselector, which is fitted with both forward and backward drive magnets.

The transmitted codes consist of twenty-five impulses, divided into two groups by a short pause. Positive impulses are used for the descriptions and negative for the destinations. The positive and negative impulses are sent alternately at the rate of eleven per second. The total time for transmission and checking back of a full description is approximately four seconds. The codes are sent from box to box, using the "constant total" impulsing system, which eliminates much of the delay experienced in older kinds of apparatus where elaborate "check back" circuits were used.

For transmission over each section of each running line there is one pair of line wires (40 lb per mile A.S.P.C. cable), which means that in general four pairs of wires are required throughout the system.

Power is supplied from 50V lead-acid batteries, the capacity of which varies according to the size of the installation at any particular place. Each battery is charged by a 110V a.c. feed from the signalling power supply system. Battery and charger connections are made with 7/·036 or 7/·044 "Ite" wire and the connection between cubicles and indicators with multi-core switchboard type cable. The indication lamps on the various panels are supplied from the 110V a.c. system, the voltage being stepped down by 110/12V transformers. All the display lamps are in duplicate, one lamp of each pair in the "description" indications being under-run.

The equipment was designed, manufactured and installed by Siemens and General Electric Railway Signal Company, Ltd., to the requirements of Mr. A. Moss, Signal and Telecommunications Engineer, Eastern Region, British Railways.

The Effect of Sudden Load Fluctuations on the British Grid

ABNORMALLY rapid and heavy load fluctuations on the Grid system can impose a severe test on the operations staff, since electricity on the public system cannot be stored and must be used as it is generated. Sometimes the incidence of the fluctuations can be foreseen even though the magnitude of the load variation and its rate of change can only be the subject of intelligent guess-work.

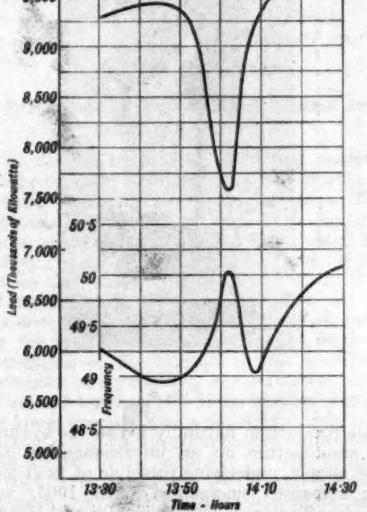
Some idea of the complexity of system control is given by the following account of the operating conditions imposed by the heavy and sudden variation in demand during the two minutes' silence that marked the funeral of His late Majesty King George VI, at 2 p.m. on Friday, February 15th. The accompanying curves show the load fluctuations and the associated changes in the frequency of supply.

The load figures are based on frequent spot readings, making no allowance for the effect of frequency variations from normal or any consequent changes in system voltage. As the reduction in demand due to the two minutes' silence could not be estimated beforehand with any degree of confidence, the consequent variations in frequency were unpredictable. To prevent the frequency reaching a dangerously high level with the sudden fall in load on generating plant, it was reduced beforehand to approximately 49 c/s. The subsequent rates of change were abnormally high, exceeding at times 0·25 cycles per second per minute. Then for the five minutes immediately following the silence the mean rate of rise in demand exceeded 330MW per minute, or about 7000 h.p. per second.

To meet the anticipated conditions a programme of operations was drawn up for all the generating stations in the system. Some stations, usually the smaller ones, were given programmes for decreasing the generation over a period of ten minutes, or even longer, immediately preceding the two minutes' silence, and a programme of the rise of generation immediately after the silence. Other stations were arranged to be carrying approximately full load and were instructed to be ready to reduce generation rapidly on receipt of instructions to cater for the drop in demand just prior to the silence.

Some time previously the output from a number of other stations had been purposely reduced and instructions had been given to be ready to increase generation rapidly on receipt of orders to deal with the rise in demand that would follow immediately after the silence. The reduction of output was achieved in many cases by the normal operation of reducing generation with the fall of demand at lunch time and then by refraining from increasing the generation as the demand increased after lunch. This principle of arranging for a generating station to pick up load was used in at least one case to avoid the undue disturbance which would have arisen in the locality if, due to sudden reduction in output, boiler safety valves had operated. In this particular case the generating station was adjacent to a cathedral.

Other stations were warned to be ready to drop output to a given amount of generation on instruction before the silence and to be ready to pick up the same amount, if instructed,



NATIONAL LOAD CURVE, 2 P.M. FEBRUARY 15TH, 1952

immediately after the silence. The amount of reduction programmed in this way depended upon the kind of plant and the ability of the station to change output rapidly. In many cases a drop of 33 per cent, and even up to 50 per cent, of the total output was planned in this way.

Preliminary arrangements were also made with some generating stations to operate at low steam pressure from 13.45 hours, allowing them to drop greater amounts of load than actually or provisionally programmed and to revert to normal steam pressure during the silence period so as to be in the best position to pick up generation, if necessary, at greater rates than envisaged. Another precaution was to give generating stations a prearranged import or export programme so that generation had to be reduced and picked up again to follow the fall and rise in local demand. When issuing such programmes an estimate was given of the amount of local load reduction.

The inherent flexibility of water power plant was used with advantage to control the power flow on the two North to South interconnectors (Meaford-Crewe and Peterborough-Bourne). For this purpose the co-operation of the North of Scotland Hydro-Electric Board was enlisted and special telephone communication established throughout the critical period between the National Control in London and Glasgow Grid Control Centre, which itself was in normal direct communication with the hydro-electric generating stations.

Practically the whole of the changes in demand, however, were necessarily carried on steam plant and were especially severe on generating plant in the Midlands and northern areas. In these areas the relative fluctuations in demand were more pronounced due to the greater preponderance of industrial demand, and the limited transmission capacity prevented the burden of these fluctuations being shared equally throughout the system. This disability was a contributory cause of the magnitude and rapidity of the frequency changes.

Just before the silence, while stations were reducing output by the various methods indicated, the system frequency was rising rapidly, thus tending to lessen the rapidity and magnitude of the drop in demand. Similarly, after the silence period, when generating stations were restoring output as rapidly as possible, the frequency was falling at a high rate and having the effect of reducing the rate and magnitude of the rise in demand. Because of the changing conditions of frequency, voltage and load, any assessment of the effect of the rise and fall of frequency must be very approximate. The associated curves of national demand and frequency for the period 13.30 to 14.30 hours show that the national load fell from 9400MW to 7600MW, i.e., 19 per cent. If an approximate allowance is made for the change in frequency the drop is of the order of 21 per cent. It will be noted from the load curve that, after the silence, the national demand rose above the level prior to the silence and continued to rise. The further rise was, of course, the normal after-lunch recovery, which had been deferred by the observance of the two minutes' silence.

Throughout the period transmission line loadings were satisfactorily controlled by maintaining particularly close liaison between the system control engineers and the station engineers. This liaison involved the cessation of all other telephone traffic with the generating stations and, in addition, it was necessary to abandon completely the economic loading of generating plant during this period. The success of the operation on the part of the generating stations can be gauged by the fact that no boiler safety valves operated during the period of rapid load fluctuations.

Technical Reports

Cathodic Corrosion of a Lead Cable Sheath (Report Ref. F/T172). By G. Mole, Ph.D., F.Inst.P. The British Electrical and Allied Industries Research Association. Price 9s., postage 3d.—The report describes an investigation of the causes of severe electrolytic corrosion found to have occurred in the sheath of a plain lead-covered concentric power cable after it had lain eleven years in a duct. An electrical survey showed that, although the cable sheaths were carrying substantial traction currents, the emission current (and therefore the electrolysis) is almost entirely voltaic in origin. The source of the voltaic current is almost certainly the voltaic cell formed by the lead cable sheath and a cast iron water main buried in the soil in close proximity to the cable duct.

The case is of unusual interest because the direction of the emission current shows that the lead cable sheath is cathodic with respect to the duct water. The counter measures available against the attack are examined, and it is concluded that the best treatment available will be that of providing the cable with an insulating covering. Proposals are made for future development of the method of survey which would overcome certain shortcomings and provide more information from the measurements than is at present available.

The Development of Engineering Metrology

By F. H. ROLT, B.Sc., A.C.G.I., M.I.Mech.E., M.I.Prod.E.*

No. II—(*Continued from page 450, March 28th*)

Developments by Zeiss

After the impetus given to the study of fine measurement by the first world war, the next important phase in the development of engineers' measuring instruments began in Germany about 1920, when the firm of Carl Zeiss made a very vigorous entry into the field. Although for the most part optical in principle, these instruments were in every way suitable for use not only in standards rooms and inspection laboratories, but also in toolrooms and even production workshops.

It is interesting that one of the earliest instruments introduced by Zeiss was an improved type of hand micrometer designed to eliminate errors due to differences in "feel," and to enable measurements to be made to within 0·0001in.

Gauge testing during the first world war was hampered to some extent by inadequate supplies of comparators for use with slip gauges; the "Hirth Minimeter" was practically the only type in existence, and that was of German origin. The development of this instrument took an early place in the Zeiss programme, and they succeeded in producing a comprehensive range for internal as well as external measurements. Some of these instruments were purely mechanical in design, whilst others incorporated optical devices for obtaining the necessary magnification.

Typical of the mechanical instruments was the "Orthotest." Of robust design, this instrument consists of an accurate measuring unit supported by a stout column above a flat measuring table.

In addition to the mechanical measuring head, Zeiss introduced their "Optimeter," which makes use of the principle of the optical lever in a particularly compact form.

As in the case of the "Orthotest," the "Optimeter" measuring head is in the form of a separate unit which can be fitted into stands in a vertical position for external or internal measurements.

To take advantage of the increased accuracy provided by the "Optimeter," and at the same time to increase the range of sizes of gauges which could be dealt with, Zeiss introduced another type of comparator, in which the measuring axis is horizontal instead of vertical. This is shown in Fig. 6, where the "Optimeter" head on the right and the anvil on the left have been fitted with U-shaped attachments for measuring a ring.

Apart from the indicating micrometer, all the Zeiss instruments referred to so far depend on the use of slip gauges as reference standards. The instrument shown in Fig. 5, however, was designed for taking external measurements, up to 4in or 100mm, without reference to any auxiliary standards; it has its own standard in the form of an accurately divided glass scale. The instrument is beautifully simple in design, and is an excellent example of one which conforms with the basic principle of alignment. This principle states that the measuring unit and the axis of measurement should be in a line and not offset from each other, if errors in measurement are to be avoided from lack of straightness of slides.

For measuring lengths above 4in, Zeiss designed a new kind of horizontal machine which they made in four sizes, the smallest for lengths up to 40in and the largest to take up to 20ft. Like the vertical measuring instrument just referred to, these machines embodied their own reference scales.

Before leaving the subject of Zeiss linear measuring instruments and machines, reference should not be omitted to a type of gauge interferometer which they began to make in about 1927, based on a principle devised by Dr. W. Koesters of the Physikalisch-Technische Reichsanstalt, Berlin. This instrument uses a krypton discharge lamp as the source of monochromatic radiations. It is based on the Michelson interferometer.

Using the Koesters apparatus, the N.P.L. has recently measured gauges up to 20in in length to the extraordinary accuracy of one part in ten million on the length. This, of course, necessitates a correspondingly high accuracy in determining the temperature of the gauge at the time it is measured.

Passing on from linear measurements, Zeiss developed a number of co-ordinate measuring instruments and machines based upon the principle of the one shown earlier in Fig. 4.

In addition to instruments and machines for linear and co-ordinate measurements, Zeiss initiated a number of devices for setting out and measuring angles, the best known of which is the optical dividing head.

Gauges and Gauging Technique

The use of limit gauges for checking the sizes of work-pieces between limits has been in vogue for a century or more. It has its origin in the armament industry, where large-

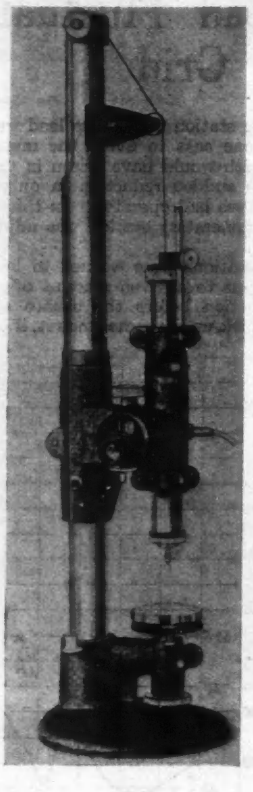


Fig. 5

scale production naturally led to the evolution of manufacture on an interchangeable basis. The simple, underlying principle of limit gauging remained unchanged until 1905, when William Taylor, of Taylor, Taylor and Hobson, Ltd., enunciated what has since become known as the "Taylor Principle." He illustrated this principle by reference to the gauging of rectangular plates intended to fit into rectangular recesses with certain margins of clearance. In order to ensure that every plate would go into every recess without fail, Taylor pointed out that it was not enough to employ simple "go" gauges for the length and breadth of each component; a control had also to be exercised on their shapes, i.e., on the squareness of the edges of the plates and recesses. In other words, the "go" gauge for the plates should be a rectangular hole, and for the recesses a rectangular plate, each gauge being made to the "maximum-metal" limits specified for the length and breadth of its corresponding component. Such gauges have since become known as "full-form" gauges—they embrace form, or shape, as well as size.

So much for proving that the two components would always go together; but Taylor continued by pointing out what was rather less obvious when one came to consider the requirements of the "not-go" gauges. He made it clear that it was useless for these gauges to be of "full-form" shape, like the corresponding "go" gauges. For example, a plate which happened to be below the lower limit on length but correctly between the limits on breadth, would refuse to go into a "not-go" gauge consisting of a rectangular hole made to the lower limits for both the length and breadth, and would thus give the false impression of not being undersize on either dimension. The correct type of "not-go" gauge for the plates would be a simple gap gauge for the length and another for the breadth; no plate should go into either of these gauges.

Taylor applied this principle of a full-form "go" gauge, and an elemental "not-go" gauge for each individual dimension of a work-piece, to gauges for screw threads. In this case, which is covered by Patent No. 6900 (1905), the full-form "go" gauges consisted of threaded plugs and rings with true Whitworth thread profiles, and with lengths equal to the length of engagement of the threads to be gauged, so as to control the pitch errors. In addition, there were three "not-go" plug gauges for the internal thread, viz., a plain plug for the crests of the threads (minor diameter) and two short threaded plugs for the effective and major diameters, with suitable thread profiles so as to operate only on the flanks and at the roots of the internal thread respectively. Similarly, three "not-go" gauges were provided for the major, effective and minor diameters of the external thread.

It is of interest to record that, in spite of Taylor's clear statement regarding the basic difference which should be recognised between "go" and "not-go" gauges for work-pieces with more than one dimension, the limit screw gauges specified on armament drawings at the beginning of the first world war consisted of pairs of high and low limit screwed plugs or rings with full-form threads. The demands for these gauges at the time were very heavy, and the limited facilities then available for their manufacture proved a serious hindrance to the adequate supply of shells, fuses and other munitions. The situation was, however, considerably eased when Sir Richard Glazebrook, at that time Director of the N.P.L., succeeded in getting the full-form "not-go" screw gauges abolished, and by so doing reduced the number of screw gauges required by nearly half. For the most part, these gauges were replaced by simple "not-go" plain plug or gap gauges for the crests of the threads, which ensured an adequate depth of engagement between mating components; only in a few special cases were "not-go" effective diameter gauges used to prevent the acceptance of thin threads.

It was not until the period following the first world war that "not-go" effective diameter gauges came into more general use, particularly in the automobile and aircraft industries. Their adoption was stimulated in this country by the revolutionary introduction of the screw calliper gauge designed by A. C. Wickman and made by the Coventry Gauge and Tool Company.

Developments by Societe Genevoise d'Instruments de Physique

The well-known Swiss firm, La Société Genevoise d'Instruments de Physique has, in the course of the last fifty years or so, been responsible for many developments in the field of engineering metrology. Their present-day products cover a very wide range, and include laboratory instruments of the very highest accuracy for use in connection with basic standards of length, engineers' measuring instrument for standards-rooms and workshops, and precision machine tools such as thread grinding and jig boring machines. For the most part, the high accuracy of these instruments and machines is based on the use of precision scales. As an illustration of the order of accuracy achieved, it may be mentioned that, for one of their latest jig-boring machines with a capacity of 40in by 28in, the guaranteed accuracy

* Superintendent, Metrology Division, National Physical Laboratory.

for all settings of the work table and spindle head is 0·00015in. This accuracy is all the more remarkable when it is realised that it must involve, not only the correct spacing of every one of the 0·1in graduations on the two scales incorporated in the machine, but also perfection in the optical projection systems used for viewing these graduations, the truth of the slides, the squareness of the motion of the table with that of the spindle head, and finally the rigidity of the structure of the machine itself. The latter has to withstand the effect of the transpositions of the heavy work table and the housing of the spindle head over their entire ranges without distortion.

The scales used by the firm are made of 58 per cent nickel-steel alloy, which is favourable to a very high polish, is untarnishable, and has the same co-efficient of expansion as ordinary steel. The scales are graduated on an automatic dividing engine. The dividing engine has a

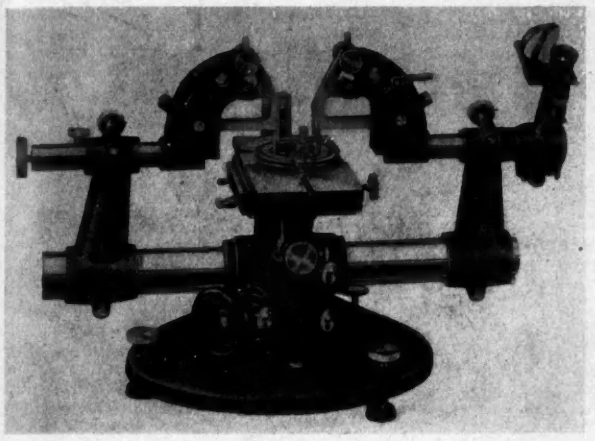


FIG. 6

compensating device for automatically correcting any small residual errors, which are determined periodically from calibrations of scales produced on the machine. The extent to which these errors can be eliminated depends ultimately upon the degree of accuracy to which the scales themselves can be calibrated. For that reason, the firm has recently devised an improved type of sub-dividing comparator fitted with a pair of photo-electric microscopes, capable of giving results to an accuracy of plus and minus two millionths of an inch.

In these microscopes, the ordinary eyepiece is replaced by a photo-electric cell which receives a succession of impulses from the image of a very narrow slit of light reflected from the scale. The slit is parallel to the lines on the scale and vibrates sideways at mains-frequency. To "set" any particular line under one of the microscopes, the scale is moved longitudinally until the line first falls within the field covered by the vibrating slit of light. The scale is then finally adjusted until the two darkening impulses caused by the passage of light across the line, first from left to right and then from right to left, occur at exactly equal intervals of time. This is indicated by a zero reading on a very sensitive micro-ammeter in an electronic circuit to which the photo-cell is coupled.

The effective magnification provided by these photo-electric microscopes can be made as high as 30,000, compared with about 100 for ordinary micrometer microscopes. In addition to their much greater accuracy, these special microscopes obviate the fatigue of taking the large number of visual microscope settings which are ordinarily required when calibrating a scale.

In its application of optical principles to engineering measuring instruments, La Société Genevoise has developed a number of compact optical projectors of the reflex type, in which the enlarged image is projected on to a translucent screen facing the operator. Within recent years they have devised a special projector for delineating the profiles of sections of objects, such as turbine blade, which defy the ordinary technique of projection. The principle used in this projector is similar to that adopted some years ago, by Messrs. Taylor, Taylor and Hobson, for viewing the sections of gear teeth, and also in a German design of machine for dealing with the sections of aircraft propeller blades.

It may be mentioned that this problem of checking the profiles of turbine blades has also been attacked in this country and in America. A machine has been designed by Solex (Gauges), Ltd., in which the blade is inserted between a number of air-gauging nozzles, distributed over its two faces. A somewhat similar scheme is used by the Sigma Instrument Company, except that the nozzles are replaced by mechanical contacts connected to signal lamps which, by their colours, indicate whether or not the profile is within the specified limit at each of the twenty-eight points gauged. Both these machines require to be set up on master blades of known sizes. A third machine made by Optical Measuring Tools, Ltd., has two feeler points which, in turn, explore the opposite sides of a section of the blade. The paths of these feelers are projected on to a screen.

Improvements in Testing Flatness and Straightness

It was not until about 1920 that analytical methods were established at the N.P.L. for making precise measurements of flatness. These methods were based on the measurement of the small angular deflections experienced by a test-block as it was displaced, step by step, across the surface, in a number of directions. These deflections were measured in the first instance by means of a sensitive level resting on the test block. By noting the successive deflections of the bubble, it was possible to determine the variations in the relative heights of the two terminal feet of the block and thence, by integration, to plot a deflection curve of the surface along the direction tested. This method was found to be sensitive to the order of 0·00001in in 10in, or 0·0001in over a span of 6ft or so. It has continued to be used for testing surface plates, machine tool beds and similar objects.

This method would not serve, however, for testing the flatness or straightness of a surface lying in a vertical plane. Here it is necessary to measure the angular deflections of the test-block in a horizontal plane, i.e., about a vertical axis. The difficulty was overcome by using an optical method based on the principle of auto-collimation. The scheme is illustrated in Fig. 7 which, for the sake of clarity, has been drawn as though the upper surface of the bed were being tested. It will be clear that, any tilting about a horizontal axis which is experienced by the mirror on the saddle as the latter is moved along the bed, will give rise to corresponding vertical displacements of the reflected image of the horizontal cross-wire. These displacements are measured in the micrometer eyepiece, and by dividing them by twice the focal length of the collimating lens, one obtains the angular deflections of the mirror or saddle, just as in the case of the level referred to above.

To test the straightness of the side of the bed, the whole of the optical arrangement on the left merely requires to be turned through a right-angle so that the cross wire is vertical, instead of horizontal.

This prototype arrangement has since been developed by Hilger and Watts, Ltd., into a conveniently arranged instrument.

The term "pneumatic gauging," or, more colloquially, "air gauging," is applied to the technique which has grown up whereby differences in size of similar objects are measured in terms of variations of air pressure in an apparatus.

Whether the variations in pressure are measured as such, or in terms of air flow, the scales of all these instruments are graduated to read directly in terms of variations in size of the object being measured. Magnifications up to 10,000 are quite commonly used, and instruments with ten times that sensitivity have been made by the Sheffield Corporation of America for comparing slip gauges.

Electrical Methods of Measurement

Up to the end of the first world war, the application of electrical principles to engineering

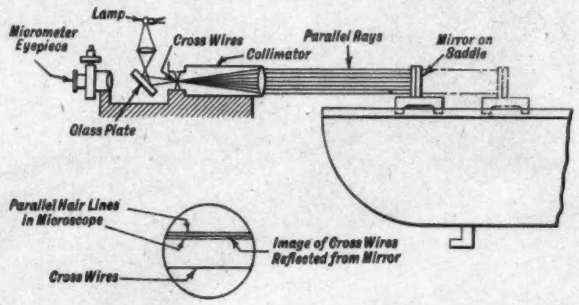


FIG. 7

measurements was very much in its infancy. Since then, however, activity in that field has considerably increased, and many types of electrically operated instruments have become available for carrying out precise measurements in workshops, standards rooms and metrology laboratories. Development took place first of all along the lines of the application of electronic valves, which offered excellent opportunities for obtaining extremely high magnifications. Oscillatory circuits were devised by R. Whiddington and J. J. Dowling, whereby small displacements of condenser plates could be detected and recorded a millionfold. R. S. Johnson also developed a carbon resistance extensometer at the Washington Bureau of Standards for recording the strains in structures —a problem to which the technique of electrical wire resistance strain gauges has since been extensively applied. These and similar devices have appeared during the last thirty years, but their uses have been mainly confined to research. For practical workshop purposes, progress in the application of electricity to measurements has been chiefly in the direction towards improving instruments and machines which utilise simple electrical contacts or the principle of electrical-magnetic induction, without having to resort to electronic amplification.

An early application of the latter principle for measuring was made in 1922 by Dr. Ford of the Admiralty Research Laboratory. It has since been developed as the "Electrolimit gauge" by the General Electric Company, Pratt and Whitney, and other organisations in America, and by Taylor, Taylor and Hobson, Ltd., in this country.

During the last fifteen years a number of gauging heads have been marketed in Germany, America and this country which operate solely on the basis of electrical contact. They were first introduced in about 1939 by the German firm, Bauer and Schaurte. The workpiece to be gauged is passed under the measuring contact of the head, which has been previously set to the high and low limits of acceptance

of the piece. If the latter lies within these limits, a small green signal lamp marked "OK" is illuminated; if oversize or undersize a yellow lamp marked "+," or a red lamp marked "—" lights up, respectively. This type of gauging head was developed in this country by the Sigma Instrument Company.

The manufacturers of these machines have displayed considerable ingenuity in adapting them to special requirements. They have designed some capable of gauging as many as twenty-eight dimensions on a fair-sized work-piece, and others which will deal with relatively small pieces, only about ½in in maximum size, with seven gauging dimensions.

The use of multi-gauging machines for mass-produced parts is steadily growing, not only in this country, but also in America, where they are now being manufactured by most of the leading gauge-making organisations.

Metrology and Machine Tools

Metrology has played no small part in the general improvement of machine tools as we know them to-day. The availability of a wide range of measuring tools and instruments, and the systematic inspection of machines to recognised codes of accuracy have undoubtedly produced their beneficial effects. In the latter connection, credit is due to the late Dr. Schlesinger for his valuable work in instituting his scheme of "alignment charts" for machine tools.

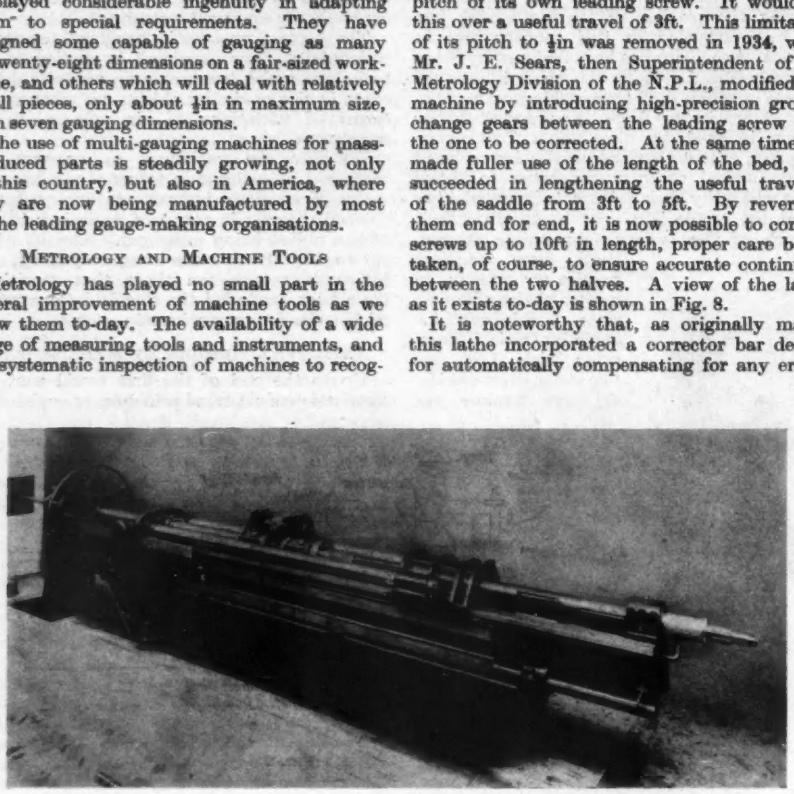


Fig. 8

In addition to this general improvement, however, very great strides have been made in the inherent accuracy of certain classes of machines by designing them in such a manner as to take advantage of the new techniques which have become available, from time to time, in the sphere of precise measurements. Jig boring machines are a familiar example of this class of machine tool. But before going into some of the details of these machines, it may not be out of place to say a few words about a certain machine which, for the last fifty years, has proved to be a considerable asset to the British machine tool industry.

This machine, known as the standard leading screw lathe, was installed in the Metrology Division of the N.P.L. in 1904 as the outcome of the work of a committee, set up by the Government in 1900 "to consider the provision of standard leading screws for screw-cutting lathes." One of the main reasons for the setting up of this committee was the lack of interchangeability which then existed in the breech screws of guns, due to errors in the pitch of their threads.

The machine was designed by the committee in collaboration with the makers, Armstrong, Whitworth and Co. It is characterised by simplicity of design and sturdiness of construction—two factors which have contributed much to its accuracy. Its own leading screw is unusually large, being 4½in diameter with a ½in pitch square thread. It is hollow and is supported centrally in bearings over one-half of the 20ft bed of the machine, which rests geometrically on three feet. A screw to be corrected in pitch is supported in a cradle bearing over the other half of the bed, in line with and coupled to the leading screw of the machine. The saddle carrying the threading tool is connected to the nut by a tie-bar on each side.

As originally designed, the screw to be corrected was coupled directly to the end of the leading screw, so that the operation of the machine was confined to copying the ½in pitch of its own leading screw. It would do this over a useful travel of 3ft. This limitation of its pitch to ½in was removed in 1934, when Mr. J. E. Sears, then Superintendent of the Metrology Division of the N.P.L., modified the machine by introducing high-precision ground change gears between the leading screw and the one to be corrected. At the same time, he made fuller use of the length of the bed, and succeeded in lengthening the useful traverse of the saddle from 3ft to 5ft. By reversing them end for end, it is now possible to correct screws up to 10ft in length, proper care being taken, of course, to ensure accurate continuity between the two halves. A view of the lathe as it exists to-day is shown in Fig. 8.

It is noteworthy that, as originally made, this lathe incorporated a corrector bar device for automatically compensating for any errors in the pitch of its leading screw. It is also interesting to note that the report of the committee responsible for the lathe states that this device was copied from a lathe made by Donkin, as early as 1826, which was in the South Kensington Museum.

After its installation at the N.P.L., the traverse of the saddle of the standard lathe was calibrated by reference to the ½in graduations along a standard scale; it was also checked at 1in intervals against a set of Whitworth end gauges. Close agreement was obtained between the two methods, and after slight adjustment of the profile of the corrector bar (at the rate of 0·016in per 0·0001in of correction required), the report records that no error more than 0·00015in was present throughout the 36in traverse (at 62 deg. Fah.). Carried out nearly fifty years ago, this must be regarded as a very fine piece of work. At the present day, the 60in traverse is correct to within 0·0001in at 68 deg. Fah.

Since its installation at the N.P.L. this standard lathe has been of national use to the engineering industry. All the leading machine tool makers have taken advantage of the facilities which it offers and have had the leading screws of their own master lathes corrected upon it.

Jig boring machines have now become so familiar in tool rooms that it is difficult to realise that their development has been confined to the last thirty years or so. The first of these machines appear to have been introduced by Pratt and Whitney; they were of the "drill-press" type, and the co-ordinate settings of their tables were obtained with micrometer screws, the accuracy of which was prone to suffer from wear. Later on, these settings were made by means of end rods associated with a dial indicator to ensure constancy of contact pressure. In one of their latest designs of machines, the firm has introduced an electromagnetic device for positioning the table, based on their "Electrolimit" gauging system. This device comprises two master bars of steel, which are fastened underneath the table at right-angles to each other. These bars are provided, not with graduation lines, but with narrow transverse projections, the "magnetic centres" of which are spaced at 1in intervals to an accuracy of ±0·00002in throughout the thirty-six and sixty lengths of the bars. Each bar has associated with it on the base of the machine an electromagnetic head, coupled to an indicating meter, which serves to show when any one of the projections is positioned exactly above it. Each of the heads can be moved relative to the bed by means of a 1in micrometer screw, graduated to read directly to 0·0001in.

To set the table in either of its directions to any given reading, the corresponding micrometer screw is first set to the decimal part of the reading; the table is then traversed by a screw until the appropriate projection on the bar arrives centrally over its electromagnetic head, as shown by a zero reading on the meter. The only possible seat of wear and deterioration of accuracy in this system of positioning the table is in the 1in micrometer heads, and as the operating pressure of the heads is only a few ounces, the risk of wear here is negligible.

Measurement of Surface Finish

Engineers have been conscious for many years of the influence of the type and degree of finish of surfaces upon the rate of wear and quality of fit of mating components. Notes such as "rough turn," "fine turn," "smooth," &c., and symbols such as *f*, *ff*, *fff*, &c., appeared on drawings many years ago in an attempt to define the type and quality of the surface required. It was not until about 1930, however, that more definite means began to be sought for specifying the finish of surfaces in terms of some scale of units analogous, for example, to the scales used for expressing hardness, in Brinell and Diamond Pyramid numbers. This quest prompted research engineers to investigate possible methods of measuring the magnitudes of the scratches and irregularities which are ordinarily present in surfaces, in the hopes of formulating some practicable scale which would meet the requirement. Their efforts during the last twenty years have been rewarded by many possible solutions to the problem. The most practicable have been developed into several forms of industrial instruments which are now to be found fairly widespread in those branches of industry concerned with the manufacture of the more precise classes of work. A scale of values for designating grades of surface finish has also been devised and is recommended in British and other national standards for use on drawings, and instruments are available based on that scale.

As in the case of ordinary measuring equipment, the various research engineers engaged on this problem of measuring surface finish made use of mechanical, optical, electrical and pneumatic techniques as possible means of obtaining the necessary high amplification of the relatively small magnitudes involved.

Generally speaking, the methods can be divided into two groups—those in which the irregularities in the surface are measured directly, or indirectly. Of the direct methods, the most successful are those in which the surface under test is traversed by a fine-pointed stylus, the small up and down movements of which arising from the irregularity are amplified, and either recorded continuously on a chart, or are averaged electrically and the result shown on a meter. Other direct methods are based on measurements of transverse sections of the surface which are produced mechanically or by some optical device. The indirect methods take advantage of some physical characteristic of the surface such as its ability to reflect and diffuse light, to function as one plate of an electrical condenser, to form an airtight joint with a smooth test piece, or to withstand the compressive effect of a locally applied load.

Measurement of Gears

The author regrets that time does not permit of a detailed account of the development of

the metrology of gears. This is an art in itself, and will have to be left to another occasion. It may be mentioned, however, that the advancements made in this field from the simple gear-tooth vernier of fifty years ago are comparable with those reviewed in other fields. Machines are now available for measuring and graphically-recording errors in the spacing and shapes of the teeth of gears ranging in size from the smallest, up to those many feet in diameter, met with in large marine reduction units. As is almost invariably the case, the progressive availability of this measuring equipment has materially assisted in bringing about very considerable improvements in gear-cutting methods and machines, which in turn have been reflected in the greater reliability and smoothness of running of gears, as we know them to-day.

The reference to marine gearing presents the writer with the opportunity of paying tribute to the achievements of the late Dr. G. A. Tomlinson in the field of engineering metrology. During the thirty years which he spent in the Metrology Division of the N.P.L., Tomlinson specialised in problems relating to the measurement of surface finish and gears. Like his colleague, E. M. Eden, to whom reference was made earlier in this paper, he possessed a very fertile imagination and was responsible for a number of novel measuring devices. He will perhaps best be remembered for his surface finish tester, and the various instruments and machines which he designed in conjunction with the Admiralty and Lloyd's Register of Shipping for checking the accuracy of large gears.

One may ask, what of the future of engineering metrology? It is difficult, of course, to predict with any certainty the lines along which future developments will eventually take place; nevertheless, it is possible to give the following indications of the present trends of advancement:—

(*a*) The establishment of a definite numerical relationship between the yard and metre lengths.

(*b*) The use of micro-wave interferometry and other optical methods for large-scale measurements in mechanical engineering.

(*c*) The use of harder materials for prolonging the life of gauges.

(*d*) The increased use of recording methods of measurements which enable the results of tests to be seen at a glance from a chart, rather than from a study of numerical values obtained from laborious analytical measurements. One might call this process the "mechanisation" of measurements.

(*e*) The incorporation of more measuring devices on machine tools to provide better opportunities for work to be produced correctly in the first instance.

(*f*) The increased use of automatic methods of gauging with their resulting economy of labour and usage of ordinary gauges.

(*g*) The provision of simple comparative instruments for use in workshops for controlling grades of finish during the course of production.

(*h*) The study of the particular grades of surface finish best suited to meet the various functioning requirements of mating components.

The writer feels proud of the part which British industry has played in the past in improving the art of engineering measurements, the importance of which in relation to the work of the Production Engineer, and thereby to the general economic progress of the country as a whole, is now generally recognised. It gives him satisfaction to know that we possess, in this country, a branch of industry with the necessary skill and enterprise to meet the continual requirements for measuring tools and instruments, not only of established designs, but also those for special purposes and of increased accuracy.

A Research Institute Canteen Building

At the Fulmer Research Institute, at Stoke Poges, which was opened in July, 1947, for the purpose of carrying out sponsored research, a canteen has recently been built for the use of the laboratory staff, which has doubled since the Institute was founded. The new building, which forms part of a larger project, is arranged to take the whole of the staff at one sitting, but provision has been made for two sittings when the laboratory building scheme is complete. Included in the amenities of the building are facilities for social activities and the presentation of lectures, and the space has been carefully planned to allow for this dual function.

The canteen forms the first bay of the new developments which will consist of a number of specialist laboratories housed in single-storey buildings, connected to a combined two-storey general laboratory and administrative block. Since the work of these laboratories is varied, the building arrangements have been planned with a view to flexibility, and it is possible to vary the length of individual laboratories by adding extensions in multiples of 9ft. To assist further the general construction of the building and the adding of extensions, a 3ft module in both directions has been adopted to suit a standardised partition panel and unit fittings, all of which are interchangeable.

The architects for the project are A. F. Hare and Partners, and the structure, which has just been completed by Structural and Mechanical Development Engineers, Ltd., is an S.M.D. "Alframe" building, using portal frames at 9ft centres, the frames being of 6in by 3in extruded hollow box-section in H.E.10W.P. aluminium alloy. The portal frames are designed with pinned feet and, to ensure a neat appearance at the knee joint, the gusset plate was riveted to the stanchion with "Chobert" rivets. Riveting was used to connect the rafters at the ridge, and then the rafters were site-bolted at the knee joints, after which the complete frame, weighing under 300 lb, was ready for erection. The rafters are exposed beneath the low pitch roof, which consists of 2in "Stramit" boards, supported on aluminium alloy Tee purlins, site-bolted at 2ft centres, and surfaced with bituminous built-up roofing with roof lights of curved perspex sheets. A brick outer skin with a 3in inner leaf of lightweight insulation blocks, with a conductivity of 0·21 B.T.U.s per square ft. per deg. Fah. per hour, form the cavity walls. At present, gas heating is employed, but air conditioning will be provided for the laboratories when they are built.

Canteen for the Fulmer Research Institute

A Counter-E.M.F. Cell for Colour Light Signalling

The difficulty of compensating for varying voltage in the storage battery and rectifier power supply of railway colour-light signalling systems has, it is claimed, been overcome by Nife Batteries Ltd., of Redditch, Worcester, with the introduction of a new "Nife" counter-e.m.f. cell developed specially for the purpose. It has been designed to work in conjunction with the company's "Telesels."

Current for illuminating colour-light signals is generally provided by a storage battery/rectifier installation; the battery stabilises the voltage to some extent and provides current should the mains supply to the rectifier fail. The voltage at which a battery "floats"—that is, the condition when the load on the battery is exactly balanced by the output of the rectifier—is higher than the voltage at which the battery begins to discharge. The battery voltage will tend to increase to a maximum if the output from the rectifier exceeds the load upon the battery. A mains supply failure causes a sudden drop in voltage which adversely affects the illumination of the signal. To avoid an excessively high voltage with the considerable difference between "floating" and "discharge" voltages, it is usual to employ a battery of large capacity and to arrange for the rectifier to maintain it between 60 per cent and 70 per cent charged. But there is a risk that, due to low mains voltage, the battery may be gradually discharging and that the "standby" service would not be maintained in the event of a prolonged mains failure.

The standard "Nife" railway signalling "Telesel" was designed to withstand overcharging for considerable periods without increasing maintenance. On a 12V colour-light signal installation, therefore, it is possible to use a ten-cell battery unit operating at 15V to 15·5V. At this voltage the battery remains fully charged and automatically regains its fully charged condition after a "power-off" period. The ten-cell battery begins to discharge at 13V, falling finally to 11·5V after a period depending upon its capacity.

The new "Nife" counter-e.m.f. cell provides a means of compensating for varying voltage; it is generally similar to the JK1 "Telesel" and is capable of carrying a maximum current of 4A. It has no capacity and a current passing through the cell causes a voltage of 1·9V to 2·3V to be developed across it. Having no capacity, it will deliver no current and can thus be short circuited by means of a relay.

This counter-e.m.f. cell, with a "power-off" relay connected across its terminals, is included in the circuit between the colour-light signals and the ten-cell "Nife Telesel" battery floating at 15V or 15·5V. The relay will only have to carry the maximum load imposed by the signal as the new cell contributes nothing. When first installed, or immediately following a "power-off" period, there will be a volt drop of 1·9V across the cell. The 15·5V of the battery is thus reduced to 13·6V and, allowing for 0·5V drop in the cables, the voltage at the lamps becomes about 13·1V. During the first twenty-four hours of use the volt drop across the cell rises to 2·0V. It stabilises in 100 hours

or thereabouts at 2·2V, assuming that a 12V 12W lamp is being constantly operated with periods of double this load at intervals (double yellow aspect). The voltage at the lamps is thus 12·8V. When the double yellow aspect is exhibited the voltage across the cell will increase by 0·1V and thus the lamp voltage will be 12·7V.

A mains power failure causes the "power-off" relay to short circuit the cell. The battery voltage almost immediately drops to 13V and, allowing for cable voltage drop, 12·5V is then applied to the lamps. This tends towards 11·5V as the battery discharges. The maximum variation in voltage, therefore, can never be more than 1·6V, as against 4V with the old method.

The new system involves no interruption of the circuit and a smaller main battery can be used, since it is always held fully charged. A more constant voltage is applied to the signal lamps and there is no possibility of their being overrun by a considerable amount if the mains voltage rises during "off-peak" periods. This, of course, prolongs the life of the lamps and minimises risk of failure.

The use of a resistance instead of a counter-e.m.f. cell was at one time considered; but, quite apart from possible failures, the voltage drop across a resistance is proportional to the current and the double yellow aspect would produce twice the voltage drop of the other single aspects. The increase in volt drop across the "Nife" counter-e.m.f. cell due to the double yellow is only 0·1V, which is insufficient to cause any visible variation in the light intensity.

The Iron and Steel Institute

THE eighty-third annual general meeting of the Iron and Steel Institute will be held in London on Wednesday and Thursday, April 30th and May 1st. The morning session on April 30th will take place at the Royal Institution of Great Britain, Albemarle Street, W.1, beginning at 9.45 a.m., with the presentation of the council's annual report. During the session the Bessemer Medal will be presented to Mr. H. H. Burton, of the English Steel Corporation, Ltd.; the Sir Robert Hadfield Medal to Dr. L. Reeve, of Appleby-Frodingham Steel Company; and the Williams Prize jointly to Mr. J. A. Bond, of Appleby-Frodingham Steel Company, and Mr. T. Sanderson, of Workington Iron and Steel Company. Captain H. Leighton Davies is to be inducted to the presidential chair of the Institute and will deliver his address. At 11.45 a.m. the sixth Hatfield Memorial Lecture, entitled "The Flow of Metals," will be given by Professor E. N. da C. Andrade, D.Sc., F.R.S.

The afternoon session on April 30th, beginning at 2.30 p.m., will be at the Institute's offices at 4, Grosvenor Gardens, S.W.1. The following papers will be presented for discussion:—"Cold Rolling with Strip Tension," by H. Ford, F. Ellis and D. R. Bland; "Effect of Tension on Torque and Roll Force in Cold Strip Rolling," by W. C. F. Hessenberg and R. B. Sims; "Pressure Distribution Between Stock and Rolls in Hot and Cold Flat Rolling," by C. L. Smith, F. H. Scott and W. Sylwestrowicz; and "Softening of Metals During Cold Work," by N. H. Polakowski. On Wednesday evening, April 30th, the Institute's annual dinner for members and their guests will be held at Grosvenor House, Park Lane, W.1, at 7 for 7.30 p.m.

On Thursday, May 1st, the morning and afternoon sessions of the meeting will be at 4, Grosvenor Gardens. The first begins at 10 a.m. with discussion on the following papers: "An Experimental Furnace for the Investigation of Open-Hearth Furnace Combustion Problems," by J. R. Hall and A. H. Leckie; "Measurement of Air Infiltration in Open-Hearth Furnaces," by R. Haynes; and "Aerodynamic Factors Associated with the Wear of Open-Hearth Furnace Roofs," by J. A. Leys and E. T. Leigh. In the afternoon at 2.15 p.m., the papers for discussion are:—"The Determination of Hydrogen in Liquid Steel," by R. M. Cook and J. D. Hobson; "Diffusion of Hydrogen in Iron and Iron Alloys at Elevated Temperatures," by P. L. Chang and W. D. G. Bennett; Distribution of Hydrogen in Large Ingots and Forgings" and "The Effect of Hydrogen on the Properties of Low-Alloy Steels," by J. D. Hobson and C. Sykes.

The Institute has given preliminary intimation that an autumn meeting will be held in Swansea from October 7th to 10th. The programme will include visits to works in South Wales.

Continental Engineering News

(By our Continental Correspondent)

The Semmering Tunnel, Austria

A new railway tunnel through the Semmering, the range which divides Lower Austria from Styria, about 60 miles south of Vienna, is at present being constructed. Before the war the Alps were crossed at this point by a double-track tunnel, built in 1852, which was a remarkable technical achievement at the time of its construction. With the increase in volume of modern traffic, the old Semmering tunnel became inadequate, and it was decided to cut a new independent single-track tunnel, the pre-war tunnel being reconstructed and used as a single-track one. The new tunnel is situated about 320ft from the old one; it is some 5000ft long, with a diameter generally of 33ft. It was excavated by cutting a bottom heading and then enlarging to the full size. The daily (twenty-four hours) progress of excavation work averaged 8½ft for the heading and 6½ft for the enlargement. The construction of the new Semmering tunnel started in October, 1949; it is hoped to complete the structure this year.

Bridge Reconstruction in Germany

Some noteworthy work has been carried out by German engineers in the extensive bridge reconstruction which has been necessary since the end of the war. Three bridges recently erected over the Rhine are specially worth mentioning. They are the Cologne-Deutz, the Bonn-Beuel and the Dusseldorf-Neuss bridges. All these bridges are of steel plate girder construction. The Cologne-Deutz bridge was described in this journal on March 17, 1950; it is a box sectioned continuous structure, with three river spans of 430ft, 605ft and 396ft long respectively. The bridge between Bonn and Beuel was completed about one year after the Cologne-Deutz bridge and is of the same general design. It has three river spans of 325ft, 642½ft and 325ft; the girder depth in the middle of the central span does not exceed 10ft. Both bridges are slender structures of a very pleasant appearance.

The Dusseldorf-Neuss bridge also crosses the Rhine and is of plate girder construction. It was opened to traffic a few weeks ago and replaces a lattice girder bridge, destroyed during the war. The new Dusseldorf-Neuss bridge has three river spans of 338ft, 675½ft and 338ft, and its overall length amounts to some 2600ft. Structurally, the bridge consists of two main girders of box-shaped cross section, 24½ft wide, spaced 20ft apart. The decking accommodates two carriageways, each 24½ft wide, a double track tramway line and two cantilevered footpaths, each 14ft wide. The main girders are 25½ft thick at the springings and 10·9ft at the crown. The central span, with its length of 675½ft, may be considered at present as a record span for steel plate girder bridges. About 6200 tons of steel was used on the contract, of which about 5000 tons was of steel of high welding quality. The steel superstructure was assembled by electric arc welding. The erection was carried out on the cantilever principle. The cost of the new Dusseldorf-Neuss bridge amounted to 10·6 million D.M. (about £820,000).

French Engineering News

(By our French Correspondent)

Following criticism by the Academy of Medicine, the purity of the water supply of Paris has recently been under discussion. Paris now consumes about 733,000 cubic metres of water daily (1 cubic metre is equivalent to some 220 gallons), which is purified at thirteen different plants, generally by the addition of calcium chloride. Consumption is nearer a million cubic metres daily in the summer and the supply is barely adequate. The ideal solution for improving the supply, it is stated, would be to bring water from the Loire Valley. However, such a scheme would cost at least £75 million, and there is little likelihood of it being undertaken for some time; various alternative proposals are being investigated.

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The Paris Municipal Council are to discuss several plans for modifying the centre of the city, to give adequate facilities for modern traffic. A scheme drawn up by Monsieur André Thirion includes three principal thoroughfares, each between 50m and 60m in width. In the centre of the city they would be underground, involving the clearing of a large part of the city, including the St. Lazare station. One complete section in the city, a business section, would be demolished, and Monsieur Thirion has drawn up plans for the establishment of office blocks, each with thirty floors, near the same district. It is thought that if the municipality could spend £5 million annually, out of a total budget of £71 million, work on such a project could be started. Half of this sum would be used for the construction of vehicular tunnels, and within a period of ten years and at a cost of £50 million, the entire scheme would be completed.

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In 1951, France imported 13,700,000 tons of coal, including 600,000 tons from Britain. This compares with 20,700,000 tons in 1938, including 6,500,000 tons from Britain. Before the war Britain was the most important supplier, but Germany has now replaced Britain. In 1938, Germany exported 5,300,000 tons of coal to France. In 1951 some 6,200,000 tons were imported from Germany.

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An extensive hydro-electric development is now being worked out in Madagascar. It is likely that a half private and half State-owned company will be formed to direct the building of several important installations. The capital will come from private sources in Madagascar and from Electricité de France and the Central Electricity Fund of the French Union.

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The Société Maritime Shell has announced that it has ordered a new 31,000-ton tanker, which will be put into service in 1955. The new tanker will be 200m in length, 25·70m in breadth and have a draught of 10·40m. It will be driven by a geared turbine, taking steam from two boilers at a pressure of 42kg per square centimetre. It will develop 13,000 s.h.p. at a propeller speed of 105 r.p.m. to give a speed of 13·5 knots.

Several other important tankers are now nearing completion in French shipyards. They include a 21,500-ton tanker building at St. Nazaire, ordered by the Courtage-Transport. This vessel is 170m long between perpendiculars, 22·70m in breadth, and has a draught of 9·55m. It has a cargo oil capacity of 27,500 cubic metres, a speed of 14 knots, and is powered by a Sulzer-Loire diesel engine developing 8400 b.h.p. Two 19,800-ton tankers are also building for the Atlantic Oil Carriers.

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Two 7200-ton deadweight cargo vessels have just been ordered by the Compagnie de Navigation Cyprien Fabre for its North Atlantic service. One of them is being built by the Chantier de la Mediterranée and the other by the Chantiers de Provence. They each have a length between perpendiculars of 128·5m, a moulded breadth of 18·3m, and a depth of 11·1m. Each vessel will be powered by a Sulzer diesel engine designed to burn boiler fuel, and giving a service speed of 16·25 knots.

Industrial and Labour Notes

Weekly Earnings in British Industry

The Ministry of Labour has published the results of an enquiry which it made last October concerning the average weekly earnings in several manufacturing and non-manufacturing industries in the United Kingdom. Information, which related to the last pay week in October, 1951, was sought from about 40,000 establishments, and returns were made by about 57,800 of them, the total number of wage-earners covered by the enquiry being over 6,500,000. The figures given were the total earnings during that week, inclusive of bonuses, before any deductions were made.

The figures show that the average earnings for all the workers included were £7 1s. 1d., the individual age groups showing the following earnings: men of twenty-one and over, £8 6s.; youths and boys, £3 9s. 1d.; women of eighteen and over, £4 10s. 1d.; girls, £2 17s. 11d. Compared with October, 1938, those figures indicate the following percentage increases: men, 141; youths and boys, 165; women, 177; girls, 213; and all workers, 165. In April, 1951, when the last similar inquiry was made, the figures of percentage increases, over 1938, were: men, 132; youths and boys, 157; women, 169; girls, 202; all workers, 156. In the manufacturing group, classified as "engineering, shipbuilding and electrical goods," the average earnings in the last pay week of October, 1951, were shown to be: men, £8 12s. 2d.; youths and boys, £3 1s. 4d.; women, £4 11s. 3d.; girls, £2 17s 4d.; all workers, £7 10s. The average hourly earnings in the same group during that week were: men, 3s. 6·8d.; youths and boys, 1s. 4·7d; women, 2s 1·9d.; girls, 1s. 4·2d; all workers, 3s. 2·3d. The Ministry's report on its inquiry adds that there have been increases in the rates of wages in a large number of industries since October, 1951. It is estimated that the effect of those increases has been to raise the general level of full-time weekly wage rates in the industries included in the inquiry by between 5 and 6 per cent in the four months from November, 1951, to February, 1952. The increase in gross earnings resulting from those increases and from other factors cannot yet be estimated.

The inquiry made last October also took account of the hours worked during the pay week which was examined. It was found that the average hours worked in that week were: men, 47·8; youths and boys, 44·5; women, 41·5; girls, 42·1. In the "engineering, shipbuilding and electrical goods" group, the average hours were shown to be: men, 58·3; youths and boys, 44; women, 42·2; girls, 42·5.

Short-Time and Overtime Working

Under the Statistics of Trade Act, 1947, monthly employment returns are collected by the Ministry of Labour from employers in the manufacturing industries, with more than ten workpeople. Every quarter these monthly figures are supplemented by some particulars about short-time and overtime working in all the manufacturing industries, apart from shipbuilding and ship-repairing. These additional particulars relate only to operatives and do not include any administrative, technical, and clerical staffs.

The latest issue of the *Ministry of Labour Gazette* gives information, based on these returns, about short-time and overtime working in the week ended January 26th. The returns made by manufacturing establishments for that week covered, in the aggregate, 5,827,000 workpeople, and showed that there were 216,446 on short time, losing on the average thirteen hours. The number of workers on overtime during the same week was 1,157,668, the extra time worked being, on the average, seven-and-a-half hours. In the establishments classified under the heading "engineering and electrical goods," there were 1,175,000 covered by the returns made to the Ministry. Of that number, 2984 were on short time in the week ended January 26th, each losing on an average, eleven-and-a-half hours. The number estimated to have been working overtime was 394,836, the extra hours worked averaging eight.

Index of Industrial Production

The index number of industrial production (1946=100), which is prepared by the Central Statistical Office of the Treasury, has been provisionally estimated at 144 for January, for all industries, compared with a revised figure of 139 for December last. Figures in the corresponding months of the preceding years were 140 for January, 1951, and 140 for December, 1950. In the manufacturing industries alone in January this year, the index number has been established provisionally as 148, as against 146 in January last year. The Treasury says that, on the basis of information so far received, the index number for all industries for February this year is expected to be 148 or 149. Last February it was 151.

Price Changes

The Ministry of Materials has announced this week changes in the prices of tungsten, ground sulphur, sulphuric acid, copper and virgin aluminium. Tungsten ore of standard 65 per cent grade and ordinary quality has been reduced, as from March 31st, from £26 15s. to £25 per long ton delivered consumers' works; ground sulphur has been reduced by £1 14s. a ton, on average, or by approximately 7 per cent on current prices, and the maximum prices will no longer include an amount to cover the cost of bags or other form of package; the maximum prices of sulphuric acid have likewise been reduced by approximately 7 per cent. These price changes for sulphur and sulphuric acid have been authorised by Orders which took effect on April 1st.

The prices of copper and virgin aluminium have been increased from April 1st. Electrolytic copper has been raised in price from £227 to £231 a ton, delivered consumers' works, but the discounts and premiums for special shapes are unchanged. It is stated that the new price has been necessitated by the extent of the overhead charges—including refining—which the Ministry of Materials has to bear. The price of virgin aluminium in ingot form has been increased from £148 to £154 per long ton, delivered consumers' works, and for metal in notch bar form there is an addition of £2 10s. per ton as hitherto. The new price applies to metal of a purity of 99 to 99·5 per cent inclusive, the premiums payable for higher purity ingot remaining unaltered. The Ministry says that this price change is due mainly to the increased cost of imported supplies, although the higher cost of home-produced aluminium has had to be taken into account.

An Order made by the Minister of Supply—with effect from April 1st—increases the price of aluminium scrap. The revised prices per ton are: foil scrap for flake powder, £156; other pure aluminium scrap, £123; old rolled or extruded pure aluminium scrap, £112; clean aluminium alloy scrap, £107; aluminium turnings, £79; new pure plain aluminium foil stock scrap, £149.

The T.U.C. and Fuel Policy

In evidence which it has recently submitted to the Committee on National Fuel Policy, the Trades Union Congress has suggested the setting-up of a fuel and power council. Such a council, it considers, should be composed of representatives of the National Coal Board, the British Electricity Authority, and the Gas Council. The T.U.C. takes the view that the council should not have executive powers, but thinks that it could give the Minister of Fuel and Power valuable advice on national, rather than sectional, interests.

The T.U.C. has emphasised in its evidence that all the three fuel and power authorities are engaged on long-term plans which indicate clearly the need for a more co-ordinated policy. Among more specific suggestions put forward in the evidence is one that higher priority should be given to the manufacturers of mining machinery, and another that the National Coal Board's research organisation should be expanded. The T.U.C. also urges more efficient methods of using coal which, it says, are just as important as more efficient methods of winning it. At the same time, it expresses disapproval of higher coal prices as a means of checking misuses.

Royal Ordnance Factories

In a written Parliamentary reply last Monday, the Minister of Supply, Mr. Sandys, stated that he had decided to make certain changes in the organisation of the Royal Ordnance Factories, which were based upon the recommendations of a committee of inquiry appointed by his predecessor. The purpose of those changes was to recognise more fully the industrial character of the factories. Henceforth, the factories would be administered by a board of management which would include members drawn from outside industry.

Subsequently, the Ministry of Supply announced the composition of the Royal Ordnance Factories Board which, it stated, would be responsible for advising the Minister on matters of policy relating to the factories. Lieut.-General Sir Kenneth Crawford, the Ministry's Controller of Supplies (Munitions), is to be chairman of the board, with Mr. C. K. F. Hague, managing director of Babcock and Wilcox, Ltd., as deputy-chairman. The official members, in addition to the chairman, will be Sir Lewis Hutchinson, Deputy Secretary in the Ministry of Supply; Mr. A. G. E. Briggs, Deputy Controller of Supplies (Munitions Production); Mr. N. Baliol Scott, Director of Organisation and Methods, and Mr. T. E. Harris, Director-General of the Royal Ordnance Factories. In addition to Mr. Hague, the deputy chairman, there are to be two "non-official" members, who are Mr. H. A. Benson, of Cooper Brothers and Co., chartered accountants, and Dr. James Taylor, of Imperial Chemical Industries, Ltd. The non-official members will serve in an honorary capacity.

Transport Costs

Speaking at the annual luncheon of the Mansion House Association on Transport, on Friday last, Lord Hurcomb, chairman of the British Transport Commission, referred to the rapidity with which general economic causes had inflated, and were still inflating, the expenditure of transport undertakings. He said that, in the fifteen months since December, 1950, £47,000,000 had been added to the British Transport Commission's wages bill alone, if the indirect and consequential, as well as the direct, increases in remuneration were brought into account. All those increases, Lord Hurcomb added, had resulted from arbitrations, awards or settlements in line with what had been done in other industries.

Lord Hurcomb also mentioned oil duties which, he said, two successive Governments and three successive Chancellors of the Exchequer had felt compelled to increase. The Transport Commission's bill for fuel oil, already heavy, had consequently been increased over the last three years by no less than £15,500,000 in a full year at the current rate of consumption. Under the head of oil duties and vehicle licences, the British Transport Commission was now contributing to the Exchequer at the rate of about £27,000,000 a year. Lord Hurcomb claimed that it was not possible for the Commission to absorb increases, of the order of those he had mentioned, without increasing charges, and at the same time to pay its way, as by statute it was bound to do. This year, he commented, the Commission had to meet the full impact of the additions to its expenditure which had been imposed last autumn, well in advance of the dates at which its charges could be adjusted.

Notes and Memoranda

Rail and Road

COLONIAL RAILWAY STANDARDS CONFERENCE.—A conference on the standardisation of Colonial railway equipment opened at the Colonial Office on Monday, March 31st. The overall dimensions and basic design of various types of wagon suitable for the majority of the railways concerned were considered, and the possibility of establishing standard overall dimensions and basic design of wagon stock was examined. A proposed standard medium-weight steam locomotive, the standardisation of diesel locomotives, and the simplification and standardisation of components were also discussed. Certain problems primarily affecting colonial railway systems in Africa, such as the future standard coupler height and the standard arrangement of vacuum brake connections were examined. The conference was held under the auspices of the Colonial Office and the Crown Agents for the Colonies.

NEW ROAD TRAFFIC CONVENTION.—Parliaments of this country, Canada, Australia and New Zealand, are shortly expected to pass the Motor Vehicles (International Circulation) Bill, ratifying the United Nations Convention on Road Traffic, 1949, which aims to permit motor tourists, provided with the necessary Customs and circulation documents, to travel in most countries on their own registration numbers and national identification plaques. Hitherto, many states have neither issued nor recognised international circulation documents, and, in consequence, motorists from these countries have had to register their cars separately in each country visited. The United States, France, Czechoslovakia and Sweden have recently ratified the new Convention, and Monaco has acceded to it. The minimum of five States has thus confirmed its provisions, and it came into force between them on March 26th. Among other benefits for which it provides is the mutual recognition of national driving licences, an arrangement which has previously applied only between certain countries of Western Europe.

Air and Water

GUIDED MISSILES.—It has been announced by De Havilland Propellers, Ltd., that it has, for some time, been engaged on projects associated with the manufacture of guided weapons.

THOMAS GRAY MEMORIAL TRUST.—The Council of the Royal Society of Arts has awarded the Thomas Gray Memorial Trust prize to Mr. J. Home Dickson, for his "instrument which makes it possible to navigate a ship in fog by means of a direct comparison of a large-scale chart and [a radar plan position indicator." In 1952, a prize of £50 is offered for an essay on "The Future Development of the Cargo Liner, with particular reference to general construction, tonnage, capacity, power unit, speed, general economy and complement." A prize of £50 is offered also for a deed of professional merit.

ENGINE WORKS ANNIVERSARY BROCHURE.—This year is the 125th anniversary of the founding of the firm of Werkspoor, N.V., of Amsterdam and Utrecht, Holland. In celebration of the event the company has issued a commemorative booklet which, by means of a series of photographs, gives a survey of the many and varied products manufactured by the company during its existence. The range of diesel engines is illustrated, also reciprocating steam engines and turbines, and the photographic record shows that the company builds pumps for drainage works, sugar refinery machinery, apparatus for the palm oil and food processing industries, oil refineries, refrigeration installations, bridges and transport items such as locomotives, and many forms of rolling stock.

Miscellanea

GLASS CONTAINER PRODUCTION.—The Glass Manufacturers' Federation has stated that last year in Great Britain there was a record production of 3,600,000,000 glass containers. The value of glass components of British goods exported last year has been put at £431,474,000. The Federation has recently celebrated its silver jubilee.

ISLE OF WIGHT OIL WELL.—When the well being drilled near Ainsdale-on-Sea, Lancashire, which has reached 2000ft, is completed, oil drilling operations will be transferred to the Isle of Wight. The D'Arcy Exploration Company, the prospecting subsidiary of the Anglo-Iranian Oil Company, Ltd., intends to commence drilling close to the village of Arreton, in the middle of the island. Earlier geophysical work suggested a point on the edge of the sea, but the site selected was found by gravity survey and confirmed by seismic reflection survey.

BUILDING RESEARCH.—The Building Research Station Digest No. 40, for March, 1952, deals with the application of aluminium and its alloys to a specific range of building components. The relevant British Standards are given and sections of the digest discuss the materials and their use for windows, glazing bars, rainwater goods and decorative metalwork.

INSTITUTION OF CHEMICAL ENGINEERS.—The thirtieth annual corporate meeting of the Institution of Chemical Engineers will be held at the May Fair Hotel, Berkeley Street, London, W.1, on Friday, April 25th, beginning at 11 a.m. Following the transaction of the formal business and the presentation of medals, the president, Sir Harold Hartley, will deliver his address entitled "Chemical Engineering at the Cross Roads." The annual dinner will take place in the evening at 7 for 7.30 p.m.

IRON AND STEEL CORPORATION.—The Minister of Supply, Mr. Duncan Sandys, announced on March 24th in the House of Commons that he had appointed Mr. Robert Marshall to be a part-time member of the Iron and Steel Corporation. Mr. Marshall is a director of Colvilles, Ltd., of Glasgow, and since May 1, 1951, he has been lent to the Corporation to advise it on sales and prices. His salary as a part-time member will be £500 a year. This appointment brings the membership of the Corporation up again to the statutory minimum.

IRON AND STEEL ENGINEERS GROUP.—The next meeting of the Iron and Steel Engineers Group of the Iron and Steel Institute is to be held at 4, Grosvenor Gardens, London, S.W.1, on Thursday, April 17th. It will begin at 10.30 a.m. with a paper by Mr. L. N. Lloyd, on "The Supply and Use of Hydraulic Power at Appleby-Frodingham." A buffet luncheon will be available from 12.45 p.m. and at 2 p.m. a paper by Mr. C. G. Evans and Mr. P. L. Fairfield, on "Pump Designs and Applications in Iron and Steel Works," will be presented for discussion.

PORTRAIT OF SIR JAMES SWINBURNE.—A portrait of Sir James Swinburne, Bart., F.R.S., which has been painted by T. C. Dugdale, R.A., at the request of the directors of Bakelite, Ltd., was recently unveiled by Lady Swinburne, following a luncheon to celebrate Sir James's ninety-fourth birthday. Sir James was chairman of Bakelite, Ltd., until his retirement in 1948, since when he has been honorary president of the company. He is the senior past-president of the Institution of Electrical Engineers, having occupied the chair of that Institution fifty years ago.

AUSTRALIAN OIL REFINERY.—The Anglo-Iranian Oil Company, Ltd., is to build an oil refinery of an annual capacity of 3,000,000 tons at Kwinana, on Cockburn Sound, some 12 miles south of Fremantle, Western Australia. The site consists of 900 acres of land having good loading bearing properties and close to sheltered deep water, suitable for berthing 32,000-tons deadweight tankers. The Western Australian Government will supply water, electricity and houses, lay roads and dredge the channels through the Success and Parmelia sandbanks. The plant will consist of atmospheric and vacuum distillation units, treatment plants and a catalytic cracking unit.

SAFETY LENSES.—We are informed that J. and R. Fleming, Ltd., of 146, Clerkenwell Road, London, E.C.1, is now making safety lenses for goggles and spectacles of "Armorglas." "Armorglas" is prepared by heat-treating and cooling glass so that the resulting tensions produce a lens with tough surfaces which will withstand the impact of a heavy blow. Before it leaves the factory, each lens is tested by having a steel ball, ⅞in diameter and weighing 54 grammes, dropped on to it from a height of 54in. Lenses tested to destruction in the factory have proved to be able to withstand several blows. When "Armorglas" does break, it fractures into cubical pieces without sharp edges which, it is stated, are unlikely to damage the eye seriously.

GEARBOXES FOR ENGINE COMPRESSOR TESTING EQUIPMENT.—We are informed by David Brown and Sons (Huddersfield), Ltd., that it has received an order from the Bristol Aeroplane Company, Ltd., for a set of high-speed increasing gearboxes of special design for testing engine compressors. These gearboxes, which will replace existing plant previously supplied by the firm, have become necessary to accommodate the increased output speeds and power of the latest types of engines. One of the new gearboxes will incorporate single helical, spiral bevel and double helical increasing gears. The remaining two gearboxes will be torque reaction, coaxial units, each with two sets of double helical increasing gears. These gearboxes, which will be weighted to ensure perfect balance, will be interchangeable so as to provide alternative output speeds of 7000 r.p.m. and 10,000 r.p.m. Neglecting friction losses, the units are required to supply final drives of 10,500 h.p. (at 7000 r.p.m.) and 7000 h.p. (at 10,000 r.p.m.), respectively. The combined unit, comprising the main and one torque reaction gearbox, will be driven by four or six motors, each of 1750 h.p. at 900 r.p.m., in accordance with the power and speed requirements for test.

Personal and Business

MR. PHILIP BREMRIDGE has been appointed director of the British Independent Air Transport Association, Ltd.

THE NORTHERN IRELAND GOVERNMENT has leased a new Government factory at Coleraine to Lodge Plugs, Ltd., Rugby.

NUCLEONIC AND RADIOLOGICAL DEVELOPMENTS, Ltd., 22, Marshgate Lane, Stratford, E.15, states that its telephone number is now Maryland 4577.

MR. D. E. BAIRD has been appointed deputy chairman of the Durham Divisional Coal Board, in succession to Mr. R. S. Barrett, who has retired.

MR. J. F. H. TYLER, B.Sc. (Eng.), has been appointed assistant signal and telecommunications engineer in the Western Region of British Railways.

WAILES DOVE BITUMASTIC, Ltd., Hebburn, Co. Durham, states that Mr. Charles Macdonald, contracts manager, has been appointed to the board.

D. NAPIER AND SON, Ltd., Acton, London, W.3, announces that it has purchased the factory and plant of British Salmson Aero Engines, Ltd., Raynes Park, London, S.W.20.

MR. FELIX L. LEVY, a director of George Cohen Sons and Co., Ltd., has been elected president of the London and Southern Scrap Iron and Non-Ferrous Metal Merchants Association.

COLUMBUS-DIXON, Ltd., is the title of a marketing organisation which has been formed to handle the products of Columbus, Ltd., and R. G. Dixon, Ltd., Capitol Works, Wembley, Middlesex.

MR. ROGER FALK, formerly director-general of the British Export Trade Research Organisation, has joined the staff of Production Engineering, Ltd., to take charge of the marketing side of its work.

MR. H. B. MCAUSTAN has been appointed a director of Associated British Oil Engines (Marine), Ltd., and has resigned his position as technical sales manager of the National Gas and Oil Engine Company, Ltd.

THE DARLINGTON FORGE, Ltd., Darlington, announces the retirement of Mr. Frank Swift, who has been manager of its steel foundry for the last twenty-five years. Mr. Swift has been in the company's service for over fifty years.

THE ALPEMA AGRICULTURAL MACHINERY DEVELOPMENT COMPANY, Ltd., has been formed to specialise in the production of agricultural machinery suitable for smaller farms. The company's headquarters are at Redhill Aerodrome, Surrey. Mr. Alan B. Fraser is managing director, Mr. W. P. Ellis-Groom, sales director, and Mr. Marcus Langley, A.M.I.Mech.E., is the technical director.

SIR HENRY TIZARD, G.C.B., F.R.S., has retired from the chairmanship of the Defence Research Policy Committee. With the agreement of the Minister of Supply, the Minister of Defence has appointed Sir John Cockcroft, C.B.E., F.R.S., to be chairman of the committee. Sir John will hold this office on a part-time basis and will continue as Director of the Atomic Energy Research Establishment.

Contracts

THE BURNTISLAND SHIPBUILDING COMPANY, Ltd., has received from Huddart Parker, Ltd., of Melbourne, Australia, an order for a 4500-tons deadweight cargo vessel having the following dimensions: length between perpendiculars 320ft by 49ft breadth moulded by 29ft 5in depth moulded to shelter deck. A service speed of 12 knots will be maintained by a four-cylinder Ailsa-Doxford oil engine of 2000 b.h.p. The company has also contracted to build two 3550-tons deadweight cargo liners for the Prince Line, Ltd. Designed for the carriage of citrus fruits, the ships will have a length between perpendiculars of 322ft by 46ft 6in breadth by 27ft 9in moulded depth to shelter deck and a speed of 13¼ knots. Each ship will be powered by a four-cylinder Ailsa-Doxford oil engine of 2300 b.h.p.

British Patent Specifications

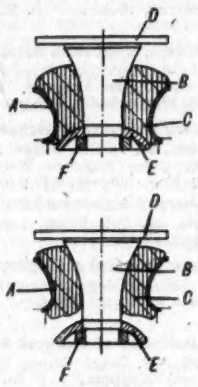
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

ROAD AND RAIL TRANSPORT

667,689. June 10, 1949.—Variable Flexibility Rubber Springs for Road, Railway and Tramway Vehicles, Conrad Allan Cook, of F. J. Cleveland and Co., 29, Southampton Buildings, Chancery Lane, London, W.C.2. (*Communicated by RIV—Officine di Villar Perosa Societa per Azioni, of* 148, *Via Nizza, Turin, Italy.*)

The spring as shown in the drawings consists of an external tubular sleeve *A*, which is secured to the wheel axle of a rail vehicle, and an internal sleeve *B* supporting the load, such as the body of the vehicle; also a rubber sleeve *C* is interposed between the two sleeves. The surfaces of the two rigid sleeves, to which the rubber sleeve adheres, are substantially conical. The internal rigid sleeve *B*



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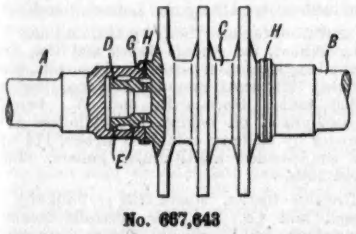
has at its end supporting the load a disc *D* and at its opposite end a shaped disc *E*. The end of the rubber sleeve is pinched between the flange of the outer sleeve and the disc *E*, and the pressure exerted by the disc is adjusted to the desired extent by a nut *F*. In this way the rubber sleeve is prestressed. When no load is applied to the inner metal sleeve the disc *E* pinches the end of the rubber sleeve against the flange of the outer rigid body. On increase of the load the pressure exerted by the shaped disc on the enlarged edge of the rubber sleeve gradually decreases till a predetermined load is reached, when the disc is drawn away from the end of the rubber sleeve. On further increase of the load the distance between the disc and the lower part of the rubber sleeve increases, the upper disc *D* approaches the rubber sleeve and, when the load reaches a determined value, bears upon it. A deformation curve is also given in the specification.—*March* 5, 1952.

GAS AND STEAM TURBINES

667,643. March 15, 1950.—Rotors for Gas and Steam Turbines, Maschinenfabrik Oerlikon, of Oerlikon, near Zürich, Switzerland.

The invention provides a rotor composed of three parts and consists of two shaft stubs, which are each welded to a rotor made in one piece, thereby having no joints in the vicinity of the discs. In the drawing, *A* and *B* denote two shaft stubs and *C* the rotor portion, which is provided at each end with a hollow trunnion *D*, only one of which is shown.



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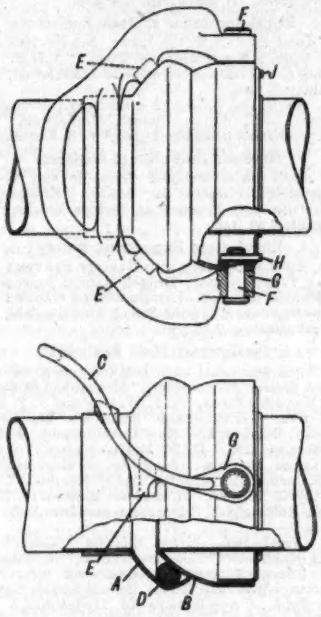
The shaft *A* is partly sectioned to illustrate the way in which the cylindrical surfaces *E* of each trunnion *D* are centred. The extensions of the shaft stubs remain relatively cool during operation of the machine and surround the trunnions *D*, which become relatively hot. The escape of air from the trunnions is permitted by grooves *G*, over which a welding seam *H* is interrupted. The construction not only increases the safety of rotors of the kind described, but it also enables welding to be reduced to a minimum.—*March*, 5, 1952.

TUBE AND PIPE COUPLINGS

667,802. October 18, 1949.—Pipe Couplings, Mannesmannröhren-Werke, of Ulmenstrasse 125, Dusseldorf, Germany.

The invention relates to quick-acting pipe couplings, more especially for artificial rain plants. The coupling *A* and *B* consists of two pipe end fittings held together by a clamping stirrup *C* with a resilient packing ring *D* interposed. The stirrup has two projections *E*, which engage the fitting *A* in diametrically opposite positions. The end fitting *B* is formed as a ball and pipe end, fitting A as a socket, and is carried on a pair of headed bolts *F*. The bolts are threaded through eyes *G* on the ends of the stirrup *C*. They are also threaded through holes in the fitting *B*, the inner end of the bolt in each case projecting for a short distance into the interior of the fitting. Extending through diametral holes in the bolts are locking pins *H*.



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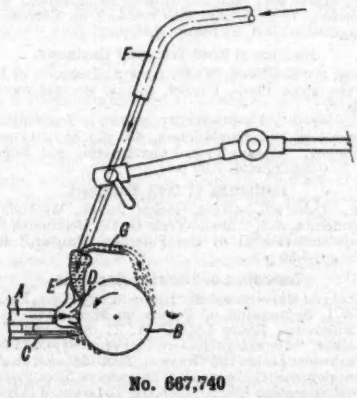
The pins *H* serve both to lock the bolts against axial movement and to prevent them turning. In consequence the forces exercised on the ends of the clamping stirrup when connecting the two parts of the coupling are transmitted to the wall of the pipe end fitting so that it is possible to employ a thinner and lighter construction for the arm portions of the stirrup.—*March* 5, 1952.

TOOLS AND WORKSHOP APPLIANCES

667,740. April 4, 1950.—The Surface Hardening of Journals, Spojene Ocelarny, Narodni Podnik, of Kladno, Czechoslovakia.

As shown in the drawing, the flame of a burner *A* acts against the journal *B*, which is rotated. The journal is heated up to the hardening temperature



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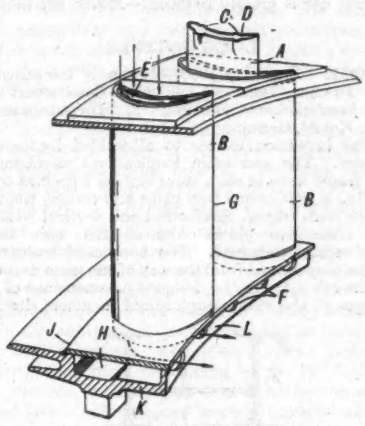
and while further rotating it is quenched by means of a water jet, the supply pipe *C* of which is assembled with the burner in a single unit. As the journal rotates further in the direction of the arrow the adjacent zones of the journal are hardened on the whole surface. At the moment when the last zone is heated the first hardened zone reaches approximately the place *D*, where the upper part of the flame would again act and detrimentally affect the hardness at this point. This danger of reheating the journal is reduced to a minimum by providing above the flame a screen *E*, which deflects the flame away from the journal. The screen is hollow and is cooled by the water which flows through the pipe *F*. It is provided at the upper end with one or more outlet pipes *G* for the cooling water, which are so arranged that the water flows down over the journal, preventing an increase in temperature in the hardened parts beyond the final quenching temperature. The screen is connected with an articulated arm and can be so adjusted that it is not subjected to the action of the flame at its hottest point.—*March* 5, 1952.

GAS TURBINES

666,536. August 27, 1949.—Stator Blades for a Gas Turbine, Armstrong Siddeley Motors, Ltd., of Park Side, Coventry. (*Inventors: Horace Sinclair Rainbow and Donald Paul.*)

The object of the invention is the effective cooling of turbine stator blades. In the drawing the core *A* of a blade *B* has at one end, and preferably at each end, at least two spaced projections *C*, which engage the interior of the wall of the blade for location purposes. The core, instead of being solid, may be formed of sheet metal. In that event the end *D* of the core, at the cooling air inlet end of the blade, is closed by a



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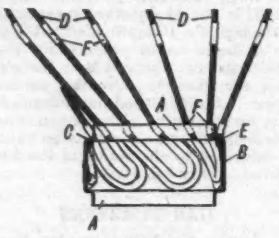
similarly shaped plate *E* welded in position. The air flow is assumed to be radially-inwardly of a blade and the cooling air travels the whole length of the blade and exhausts in an axial direction through holes *F*, as indicated by the arrows. In similar manner each of the blades may be formed of sheet metal bent to shape and having the free edges *G* of the sheet joined together. The hollow turbine stator blades are internally cooled by diluent air led from the compressor through holes in the outer ring to an annular chamber round the outer ends of the blades and then passed inwards through the blades to an annular chamber *H*, from which the air is delivered rearwards on to the roots of the first row of rotor blades in the case of the first row of stator blades. The drawing shows the annular chamber *H* as being formed by the stationary ring *J* and an inner, channel-sectioned, stator member *K* in the rearward flange *L* of which the holes *F* are formed, the ring and member being welded together.—*February* 13, 1952.

CIVIL ENGINEERING

668,350. November 29, 1949.—Devices for Cleaning the Walls of Bore-holes, Albert Edward Atkinson, "Ditton Edge," 108, Manor Road North, Hinchley Wood, Esher, Surrey.

The invention relates to devices for cleaning the walls of bore-holes, comprising a number of stiff wires or wire bristles carried by a ring. In the unit described a cylindrical metal sleeve comprises end sleeve portions *A A* joined to an intermediate sleeve portion *B* of larger diameter by shoulders *C*. All three sleeve portions are concentric. The end portions are dimensioned to fit over the bore-hole casing, and the diameter of the intermediate sleeve is such that the ends of the scratching wires can be conveniently accommodated within it. The wires *D* which constitute the scratching or cleaning elements may consist of bundled or stranded wires of suitable size and stiffness. Each wire is doubled or folded in two in the form of a narrow U-shape.

The folded portions are secured to the inside surface of the intermediate sleeve portion through holes *E* in the adjacent shoulder the ends of the wires project. The ends of the wires which extend outside the sleeve shoulder are formed to extend outwards and also in a generally tangential direction with respect to the ring axis. Small sleeves or thimbles *F* are secured over the free portion of the stranded wires, one near the sleeve shoulder and



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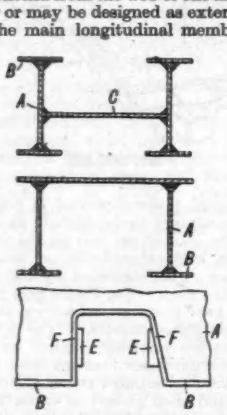
one near the free extremity, and these sleeves may be suitably angled to give the desired setting of the wire. The wires employed are preferably multiple spring steel wires, which may be either bound together by the thimbles or stranded, to give the desired stiffness consistent with the capability of returning to their original positions after use so that tangling is obviated. The invention claims to provide a more secure, robust and protected attachment for the wires than hitherto, and the risk of wires being torn from their anchorages during use is greatly reduced.—*March* 12, 1952.

LOCOMOTIVES

667,951. June 26, 1950.—Welded Locomotive Frames, Henschel and Sohn Gesellschaft mit beschränkter Haftung 2, Henschelstrasse, Kassel, Germany.

The invention relates to all-welded locomotive frames. The two main longitudinal members of the frame have in each cross section I profiles comprising a continuous web plate and flanges welded-on on both edges. Horizontal and vertical welded-on transverse plates connect the two main longitudinal members. The horizontal transverse plates may extend from the web of one main member to the other or may be designed as extensions of the flanges of the main longitudinal members directly



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connected together. At the apertures for the axle bearings the bottom flanges of the main longitudinal members form portals to replace horn blocks and guide the axle bearings. The axle bearing housings can be mounted in slide surfaces, which are disposed on the inside of the upright flange parts. In the drawings, *A* represents the web plates of the I-section main longitudinal members and *B* the flanges welded on to the plates. In the upper view a horizontal cross plate *C* connects the webs *A*, and in the centre view two upper flanges are connected by a cross plate *D*, which is an extension of the flanges. The lower view shows the portal arrangement of the lower flange *B* over an axle bearing aperture. The slide surfaces *E* for the axle bearings are welded on to the upright parts *F* of the flange.—*March* 12, 1952.

Banias-Kirkuk Pipe-line.—The Iraq Petroleum Company's 30in pipe-line from Kirkuk has been filled with oil which has now reached Banias, on the Mediterranean coast. The 30in pipe-line has been completed as far as Haditha and is temporarily linked with Kirkuk, 115 miles away, by 12in and 16in pipe-lines. The final stage of the new line is well advanced and the 556 miles from Kirkuk to Banias is expected to be ready by the end of this month.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

Mon., April 7th.—Leeds Branch: Great Northern Hotel, Wellington Street, Leeds, 1, Problems Night, 7.30 p.m.——N.E. London Branch: Angel Hotel, Ilford, "Power Station Engineering," H. D. Watson, 8 p.m.——Sheffield Branch: Royal Victoria Station Hotel, Sheffield, "Control of Machine Tools," K. M. Swash, 7.30 p.m.

Tues., April 8th.—Bolton Branch: Balmoral Hotel, Bradshawgate, Bolton, "Refrigeration." Mr. Crowshaw, 8 p.m.

Wed., April 9th.—S.W. London Branch: Evening Visit to Merton Park Film Studios, 8.15 p.m.——Bradford Branch: Midland Hotel, Bradford, Film presented by L. Bruce, 7.30 p.m.

Fri., April 18th.—Crewe Branch: Copeland Arms Hotel, Glebe Street, Stoke, "Motor Fault Locating and Rewinds," D. Bosworth, 7.30 p.m.

British Institution of Radio Engineers

Wed., April 9th.—N.E. Section: Neville Hall, Westgate Street, Newcastle upon Tyne, "V.H.F. Broadcasting: the case of Amplitude Modulation," J. R. Brinkley, 6 p.m.

Thurs., April 10th.—Scottish Section: Metropolitan-Vickers, Ltd., Watling Street, Motherwell, "X-ray Equipment and its Control Gear," C. S. Norton, 7 p.m.

Cleveland Institution of Engineers

Mon., April 7th.—Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Blast-Furnace Practice at Redcar Works," A. T. Ledgard, 6.30 p.m.

Illuminating Engineering Society

To-day, April 4th.—Bath and Bristol Centre: Royal Hotel, College Green, Bristol, annual luncheon and presidential address.—Huddersfield Group: Electricity Showroom, Market Street, Huddersfield, annual general meeting, 7.15 p.m.

Incorporated Plant Engineers

Tues., April 8th.—E. Lancs Branch: Engineers' Club, Albert Square, Manchester, "Mechanical Stokers and Coal Handling Plant," R. F. W. Guy and J. P. Lauder, 7.15 p.m.——Edinburgh Branch: 25, Charlotte Square, Edinburgh, "The Development of Modern Lubricating Oils," D. T. McHutchinson, 7 p.m.——S. Wales Branch: Institute of Engineers, Park Place, Cardiff, Ten-Minute Talks by Members, 7.15 p.m.

Wed., April 9th.—E. Midlands Branch: Welbeck Hotel, Nottingham, "Ironstone and Iron," W. Corns, 7 p.m.

Thurs., April 10th.—Kent Branch: Queens Head Hotel, Maidstone, "Toughened Glass," Demonstration and Films, 7 p.m.——Newcastle upon Tyne Branch: Roadway House, Oxford Street, Newcastle upon Tyne, "Applications of Hydraulics," D. V. Rowles, 7.30 p.m.

Institute of Industrial Supervisors

Mon., April 7th.—Dudley Section: Technical College, Dudley, "The Legal Side of Industry," H. Harman, 7.30 p.m.

Tues., April 8th.—Kidderminster Section: Carpet Trades, Ltd., Mill Street, Kidderminster, "American Foremanship Report," J. R. Armstrong, 7.30 p.m.

Wed., April 9th.—W. Bromwich Section: Wellington Tube Works, W. Bromwich, "Industrial Law," A. M. B. Rule, 7.45 p.m.

Thurs., April 10th.—Smethwick Section: Chance Technical College, Crocketts Lane, Smethwick, "Air-Operated Equipment," J. D. Emms, 7.30 p.m.

Institute of Marine Engineers

Tues., April 8th.—85, The Minories, London, E.C.3, "Some Recent Studies of Human Stress from a Marine and Naval Viewpoint," N. H. Mackworth, 5.30 p.m.

Institute of Petroleum

Wed., April 9th.—Manson House, 26, Portland Place, London, W.1. "Some Observations on Corrosion in Engineering," S. F. Dorey, 5.30 p.m.

Institute of Road Transport Engineers

To-day, April 4th.—S. Wales Group: Institute of Engineers, Park Place, Cardiff, annual general meeting, 7 p.m.

Mon., April 7th.—Scottish Centre: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Chassis Frame Construction and Repair," C. F. Cunningham, 7.30 p.m.

Institution of Civil Engineers

Tues., April 8th.—Great George Street, Westminster, London, S.W.1, "Model-Tests on the Bellmouth Spillway and Outfall of the Fassideri Project," E. S. Crump, 5.30 p.m.

Institution of Electrical Engineers

Wed., April 9th.—Radio Section: Savoy Place, London, S.W.1, Symposium of Papers on Microwave Links: "Microwave Radio Links," A. T. Starr and T. H. Walker, "Circuit Technique in Frequency-Modulated Microwave Links," H. Grayson, T. S. McLeod, R. A. G. Dunkley and G. Dawson, "Microwave Technique for Communication Links," G. King, L. Lewin, J. Lipinski and J. B. Stechfield, 5.30 p.m.——Scottish Centre: Heriot-Watt College, Edinburgh, "The Design and Performance of Surge Diverters for the Protection of A.C. Systems," T. F. Monahan, 7 p.m.

Institution of Engineers and Shipbuilders in Scotland

Tues., April 8th.—39, Elmbank Crescent, Glasgow, "Ship Structural Members, Part V," A. G. Hadjipyrou and H. Lackenby, 6.30 p.m.

Institution of Mechanical Engineers

To-day, April 4th.—Storey's Gate, St. James's Park, London, S.W.1, "Some Considerations Regarding a Factory Maintenance Engineering Department," Max Bentham, 5.30 p.m.

Tues., April 8th.—Automobile Division: Storey's Gate, St. James's Park, London, S.W.1, "Long-Distance Diesel Buses on the European Continent," J. A. Steenman, 5.30 p.m.

Wed., April 9th.—Southern Branch: University College, Southampton, "Wind Excited Oscillations of Suspension Bridges," C. Scruton, 7 p.m.——Graduates' Section: Storey's Gate, St. James's Park, London, S.W.1, "Marine Propulsion," P. R. Christopher, 6.30 p.m.

Thurs., April 10th.—Scottish Branch, Graduates' Section: Visit to Fibreglass, Ltd., 97, Hawthorn Street, Possilpark, 7.15 p.m.

Institution of Naval Architects

To-day, April 4th.—Honourable Company of Master Mariners' Headquarters Ship "Wellington," Temple Stairs, Victoria Embankment, London, W.C.2, annual general meeting, 10.15 a.m.

Institution of Post Office Electrical Engineers

Tues., April 8th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "A.C. Signalling—A Review of Current Problems," B. R. Horsfield and D. C. Smith, 5 p.m.

Institution of Structural Engineers

Tues., April 8th.—London Graduates' and Students' Section: 11, Upper Belgrave Street, S.W.1, "Bridges," H. Shirley Smith, 5.55 p.m.

Junior Institution of Engineers

To-day, April 4th.—39, Victoria Street, London, S.W.1, film evening, "The Argonarc Welding Process," introduced by R. R. Sillifant, 6.30 p.m.

Liverpool Engineering Society

Wed., April 9th.—24, Dale Street, Liverpool, Annual General Meeting, 6 p.m.

Manchester Geological and Mining Society

Thurs., April 10th.—Mining College, Wigan, "Reinforced Concrete in Modern Practice," G. P. Bridges, 3.15 p.m.

Royal Institution of Chartered Surveyors

Mon., April 7th.—12, Great George Street, London, S.W.1, "Mineral Valuations," J. N. Roberts, 5.30 p.m.

Society of Chemical Industry

Tues., April 8th.—Chemical Engineering Group: Burlington House, Piccadilly, London, W.1, "Heat Transfer to Boiling Liquids at Low Temperatures and Elevated Pressures," A. G. Monroe, H. A. Bristow and J. E. Newell.

Society of Engineers

Mon., April 7th.—Geological Society, Burlington House, Piccadilly, London, W.1, "Wood Glueing in Industry," K. A. Zandstra, 5.30 p.m.

Launches and Trial Trips

Scottish Lion, oil tanker; built by Swan, Hunter and Wigham Richardson, Ltd., for the Scottish Tanker Company, Ltd.; length between perpendiculars 515ft, breadth moulded 69ft 6in, depth moulded 38ft 4½in, deadweight 16,310 tons on 29ft 11in draught; twenty-seven oil cargo tanks, two pump rooms; four 500 tons per hour horizontal duplex steam oil cargo pumps, steam deck machinery, two 150kW diesel generators, one 75kW steam-driven generator; Wallsend-Doxford two-stroke oil engine, six cylinders, 670mm diameter by 2320mm combined stroke, 6400 b.h.p. at 115 r.p.m., two multi-tubular Scotch boilers. Trial, March 20th.

Essequibo, cargo liner; built by Harland and Wolff, Ltd., Govan, for the Royal Mail Lines, Ltd.; length between perpendiculars 415ft, breadth moulded 58ft 6in, depth moulded to shelter deck 38ft 4in, gross tonnage 5500; Harland-B. and W. two-stroke, single-acting, opposed-piston diesel engine, six cylinders 620mm diameter by 1870mm combined stroke, 115 r.p.m. Launch March 25th.

Janita, oil tanker; built by Harland and Wolff, Ltd., Belfast, for Anders Jahre and Co., Sandefjord; length between perpendiculars 540ft, breadth moulded 73ft, depth moulded 39ft 3in, deadweight 18,500 tons; Harland-B. and W., two-cycle, opposed-piston oil engine, six cylinders 750mm diameter by 2000mm combined stroke, 114 r.p.m., two single-ended multitubular boilers. Launch March 25th.

Howard Smith, steam tug; built by Hall Russell and Co., Ltd., for Australia Steamships Proprietary, Ltd., Sydney; length between perpendiculars 125ft, breadth moulded 32ft, depth moulded 17ft 3in, "Kort" nozzle; triple expansion direct-acting steam engine, 1320 i.h.p., at 118 r.p.m., steam at 200 lb per square inch from two single-ended cylindrical multitubular coal-burning boilers, steam deck machinery. Trial, March 26th.